The Chemical Age

A Weekly Journal Devoted to Industrial and Engineering Chemistry

VOL. L
No. 1280

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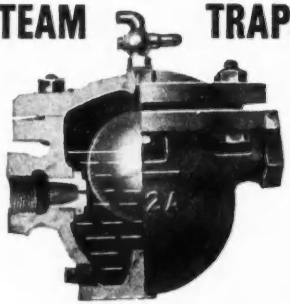

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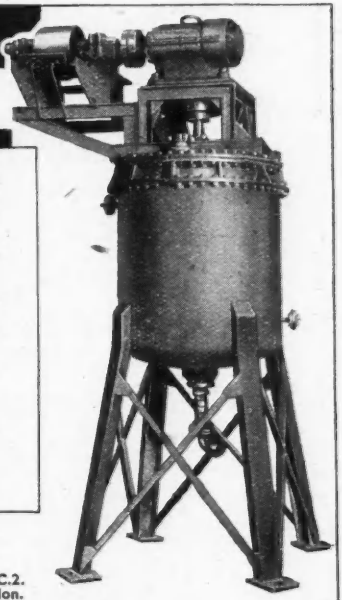

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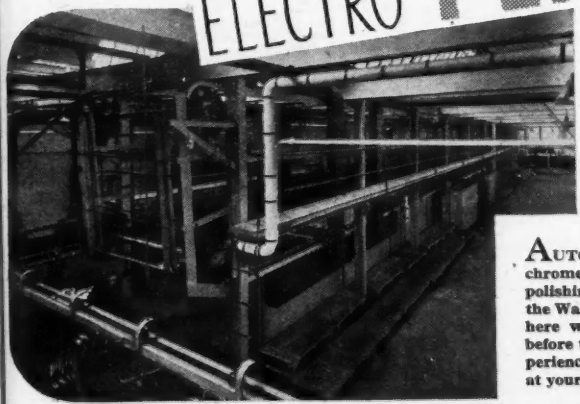

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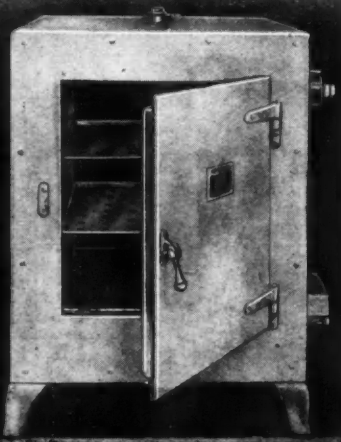

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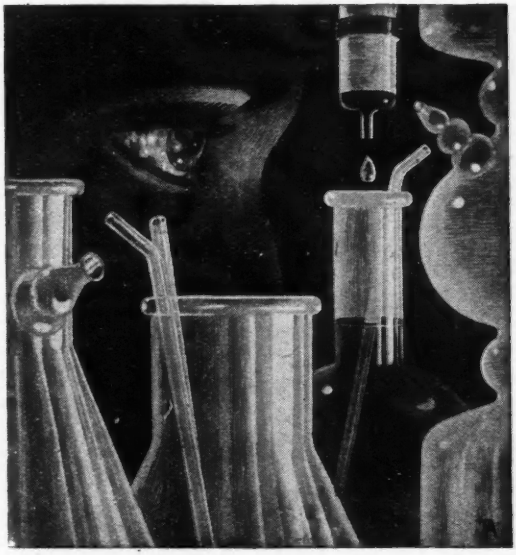

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IMPROVEMENTS in our daily life follow one another so swiftly that we tend to accept them as a matter of course. We note advances in the colour, finish and texture of our dress materials or the fabrics which go to furnish our houses. We even use without surprise entirely new types of textiles and other materials. We read with only a passing wonder of the strides being made in the prevention and cure of disease among men and animals, and for our protection, in the detection of crime. We have ceased to be astonished at the developments which make our daily round and common task, in kitchen, work-room and garden, simpler or more enjoyable. We accept without comment the progressive advance in quality of such entertainments as the cinema and radio. Even in a world at war we seldom pause to inquire how it is that we are still able to enjoy efficient substitutes for the articles which are temporarily no longer obtainable. Or how it comes about that the evils of undernourishment and the scourge of epidemic disease have been kept so firmly in control. We shall do better to remind ourselves occasionally that none of these things come of their own accord. In each one of them we shall, if we trouble to inquire, find the hand of the research chemist and of the chemical industry — and not least of the British chemical industry. The record of history shows that British chemists have always been in the van of invention and discovery. It is not the least of Britain's justifications for the regard of other nations that, even stretched on the rack of war though she is, her sons and daughters, fleets and armies scattered all over the globe, her chemists have stood to their task. Today, as in peacetime, British laboratories and chemical factories are working with undiminished resource and energy to see that the benefits of science are increasingly applied in our daily life.

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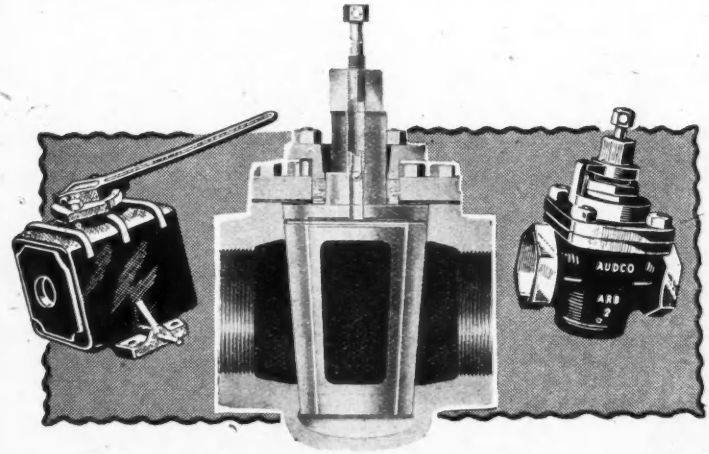

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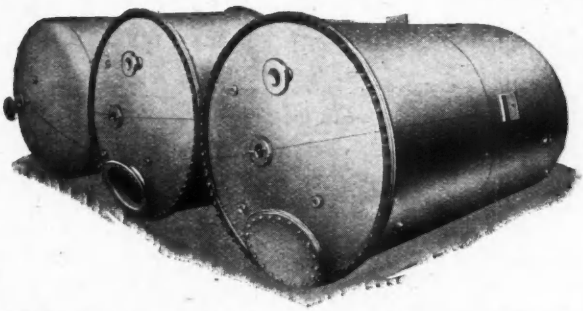

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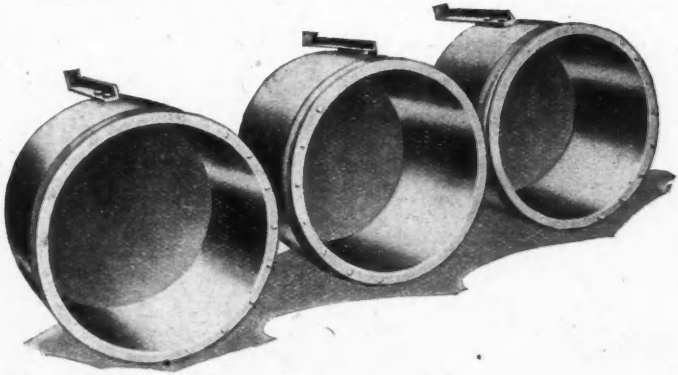

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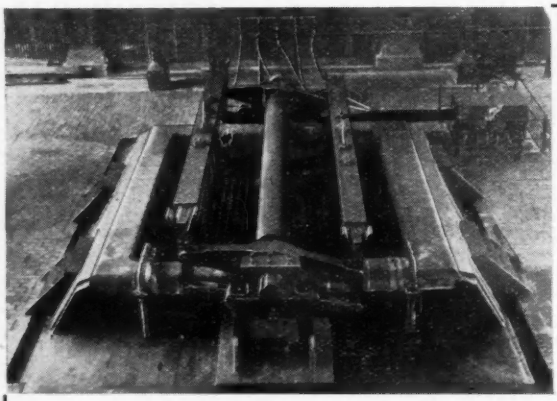

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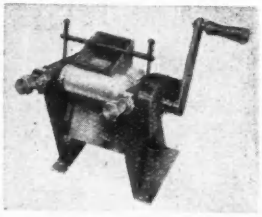

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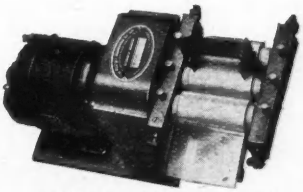

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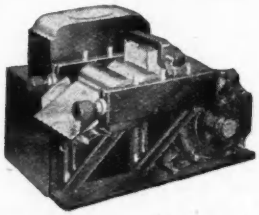

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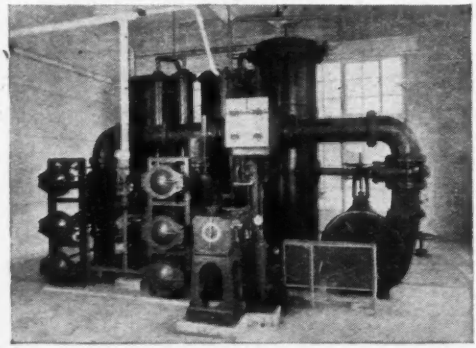

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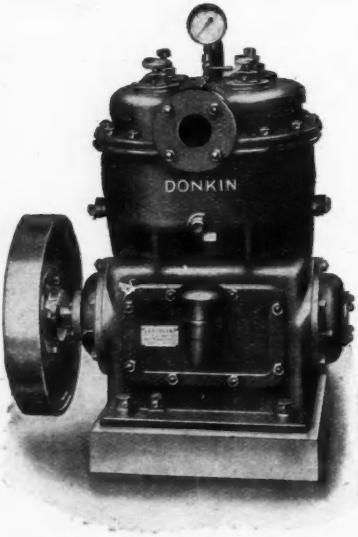

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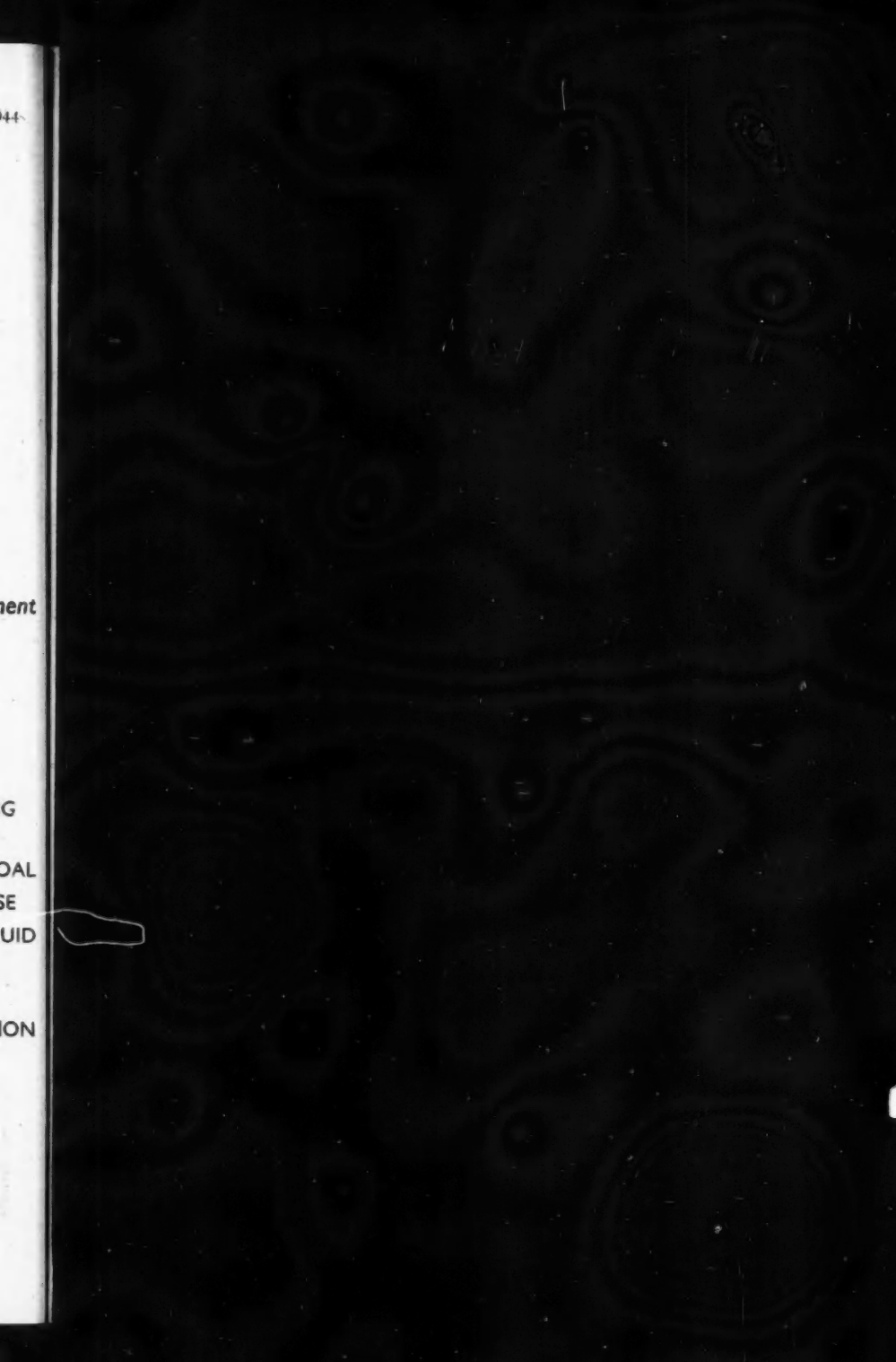

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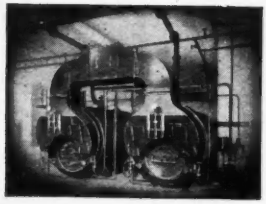

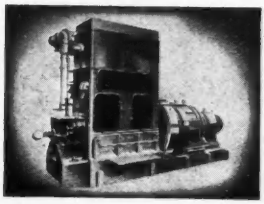

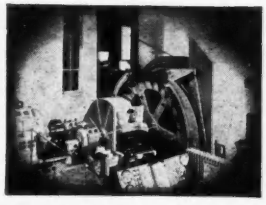

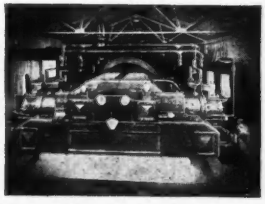

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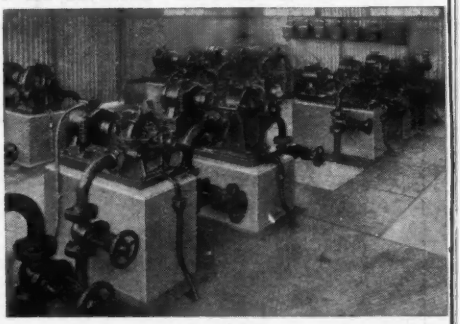

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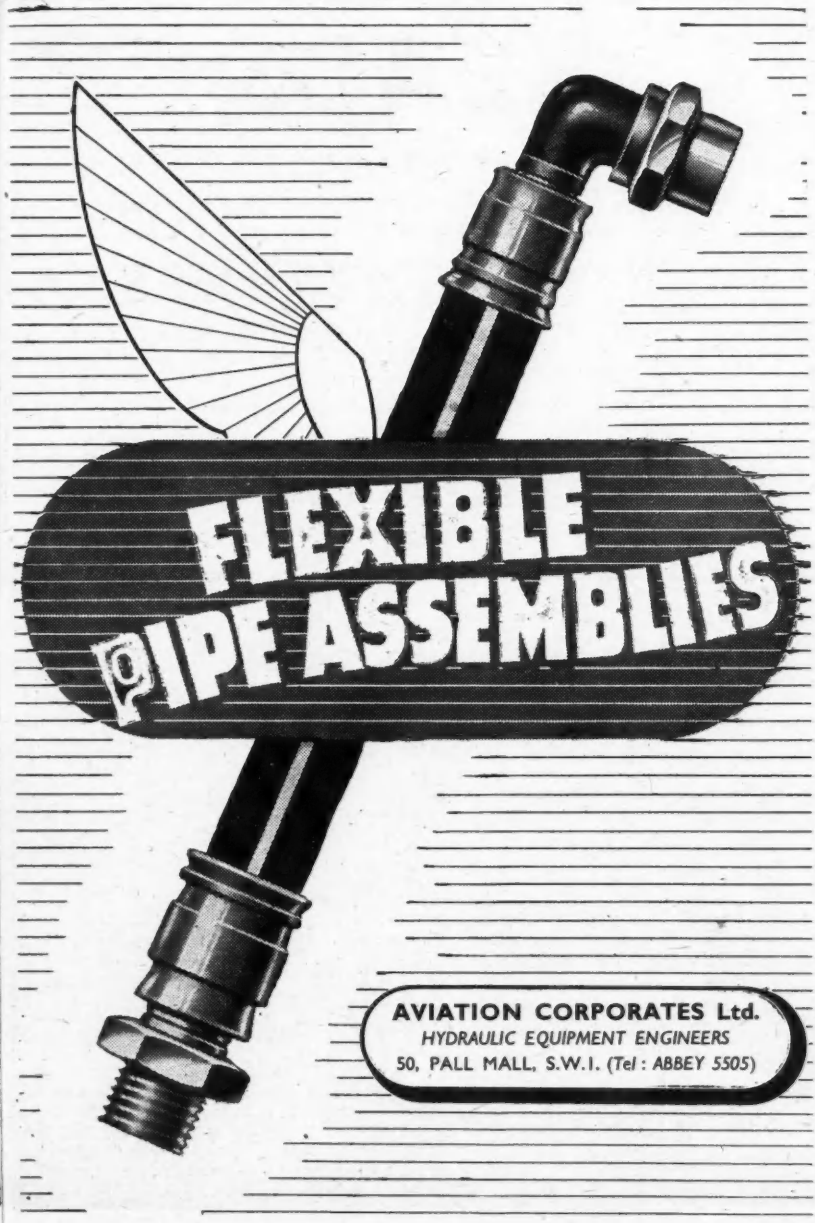
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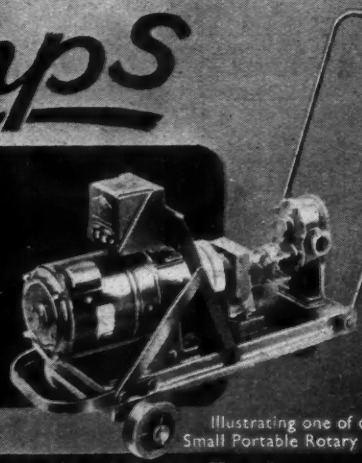

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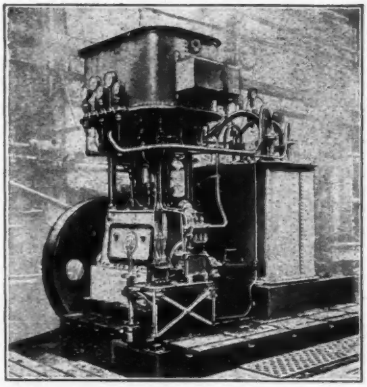

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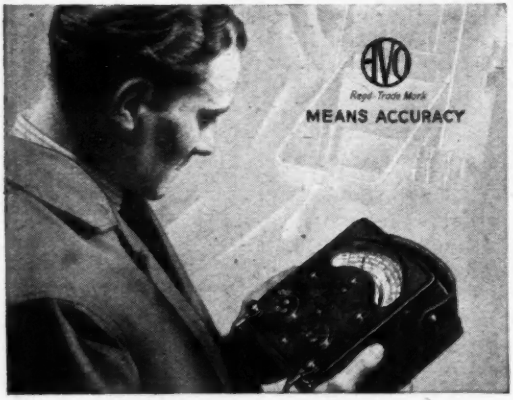

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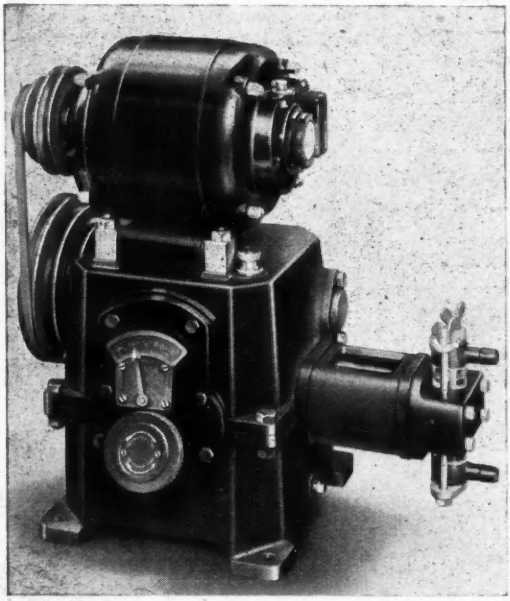

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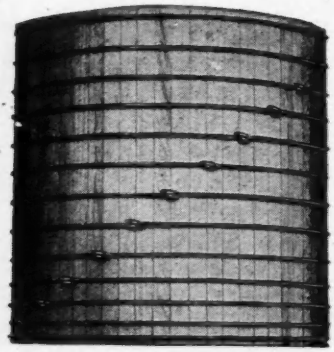

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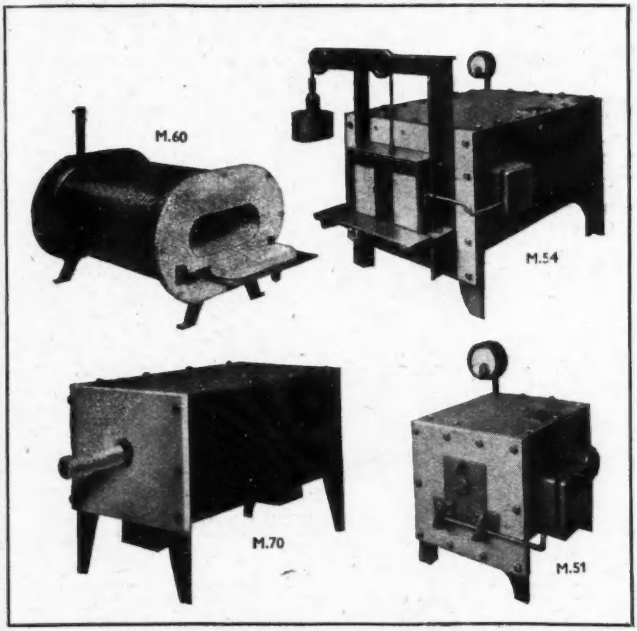

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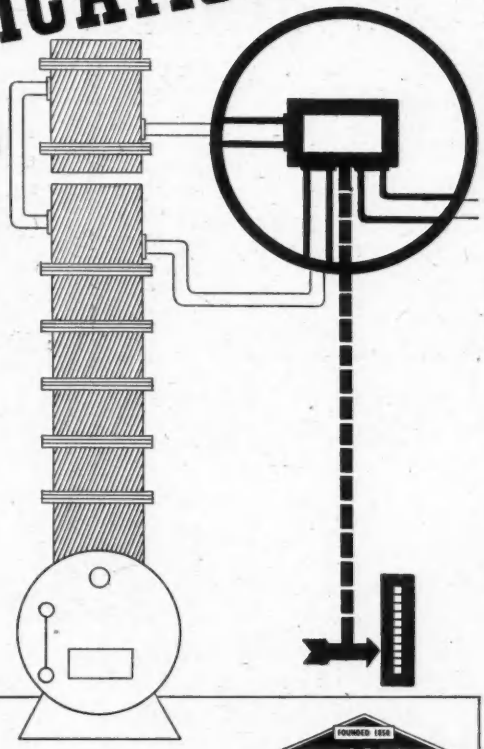

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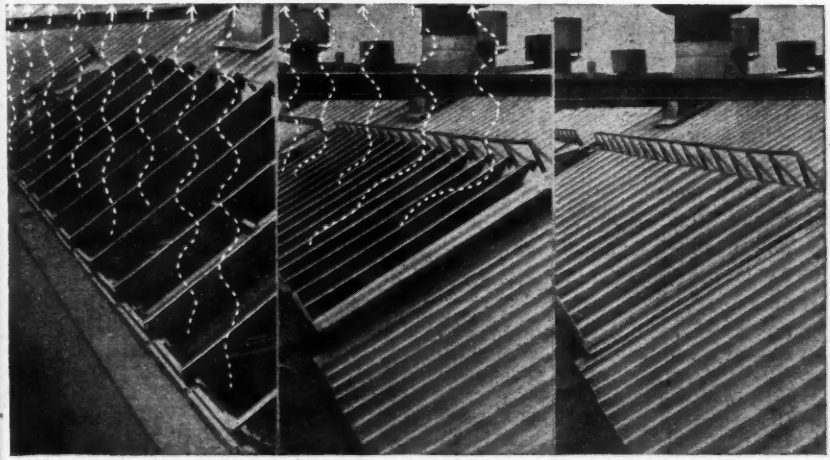

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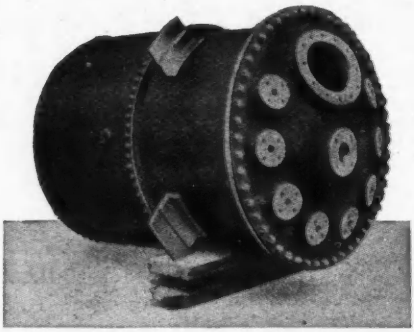

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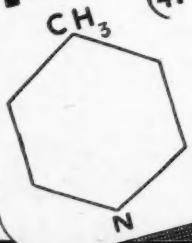

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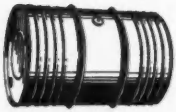

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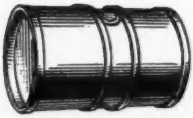

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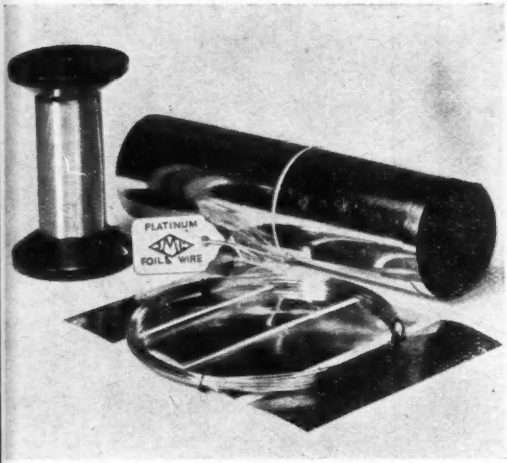

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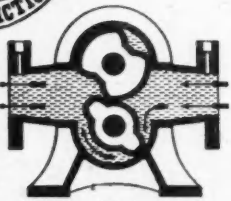

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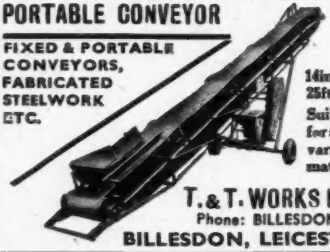

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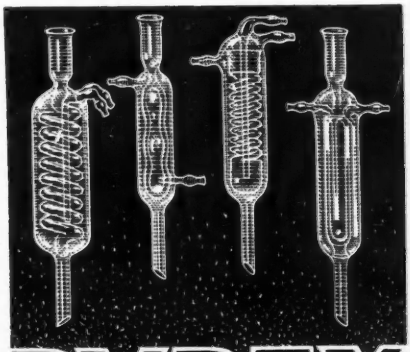

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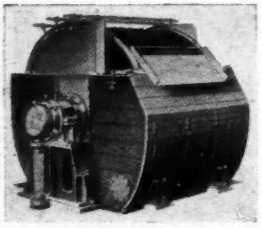

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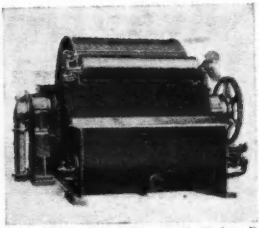

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The Future of the Chemical Industry

THERE are at least two obvious ways of discussing the future of the chemical industry. One is in relation to probable trends in markets and manufactures, and the other is the internal organisation of the industry, either in respect to its major developments in co-operation between firms, in amalgamations, and in organised planning, or in relation to the general manner in which the industry handles its problems. As Lord McGowan indicated in an address delivered a few months ago to the combined chemical societies, we may find, when we look back over the last few years, that they have been the most significant period in the history of the chemical industry. For many reasons we believe that this is true in substance and in fact. There are arising in many parts of the world new chemical processes, important new methods for the synthetic manufacture of materials equal to or superior to those previously obtained from natural sources. War always stimulates research and invention, and the chemical industry shares with the metallurgical industry the leadership of the arts of war. When the time comes, the knowledge that has been so obtained will be applied to the arts of peace.

Simultaneously, there is arising throughout the world a consciousness that the world must in future be regarded as an economic unit. Transport will have been speeded up, by the vast developments in aircraft, to a degree never before experienced. The fruits of the earth will be transported from one end of the world to the other without deterioration. Vast developments in the food industries of the world will arise from war experience. Chemical industries are springing up in unlikeley and out-of-the-way places. The realisation has come home to this country, to America, to Germany, to Russia, and to Japan, over the past ten years that chemical research and chemical development, coupled with engineering research and development, is essential if a nation is to maintain its industrial position in the new world. Let anyone make a list of the things now commonplace that were either unknown or in their infancy fifty years ago and, bearing in mind the rapid tempo of development, let him then recognise that an equal advance is likely to be made within the next twenty-five years. If with such a list before him anyone with knowledge fails to recognise the changing industrial conditions from an emphasis on manufacture to an

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emphasis on development of machinery, processes and products, he must indeed be a Rip Van Winkle.

In formulating our policy we must be clear as to the relationship between practical men of affairs (in which we include works managers and engineers) and men of more academic outlook; and in the research sphere, between universities, industry and the Government. On the research side, we should expect each firm to carry its own technical staff, sufficient to deal with its day-to-day problems and to interpret, for the benefit of the firm, published work from other sources. We should expect each industry to have its own research association. This body would have its own staff and laboratories, but would be closely associated with industry on the one hand and with the universities on the other. Its staff would carry out researches at established works, including the development of new processes, in collaboration with industrial technologists, and it would "farm out" some of the more theoretical or "pure science" problems to universities who specialise in that type of work. The Government must encourage research by grants and by a suitable taxation policy, and it needs to set up Government laboratories for the supply of certain long-range problems of importance to the whole nation, which no industrial body would be likely to tackle.

The vexed question of the chemical engineer has been ventilated during the year. Lord McGowan, for example, suggested that a large undertaking would best employ teams of chemists and engineers whereas the smaller undertaking would employ what is now known as the chemical engineer. We can understand the reason for Lord McGowan's distinction. A chemical engineer, if we except the comparatively few individuals who are in the very top flight, will generally have a knowledge of chemistry inferior to that of the chemist and a knowledge of engineering inferior to that of the engineer; his strength lies in knowing a great deal of both worlds, which enables him to visualise problems from both angles and to know his own limitation. A big concern that can pay high salaries will thus be better served by teams of two sets of individuals highly trained in their own spheres. The small concern, on the other hand, cannot afford the same expenditure on salaries and must thus be content with the chemical engineer. Over this there could be much good discussion, and it is, in fact, causing some alarm among the rising generation of chemical engineers (*see* THE CHEMICAL AGE, December 4).

The functions of the universities, in relation to industry and Government research, provide yet another contentious subject. The pre-eminent task of universities is to teach. It would appear that they should aim at a broad foundation of knowledge and of social training which should enable the individual to fit in quickly with his colleagues in industry where he would pick up the necessary experience. Since the universities are to train research workers, it is evident that they must be encouraged to engage in both pure and applied research. To suggest that research at universities should be concentrated on the study of fundamental problems, aiming ultimately at the discovery of the laws of nature, is all very well in its way, but what part are the technical departments of universities and the technical colleges to play in research? It can hardly be regarded as the best training for a research engineer to have been engaged on some fundamental work on the laws of nature. Nor would it be expected that the staff of these institutions would be fitted for that type of work, since their outlook is more practical than those of the pure science departments of the universities. It is inherent in the views expressed here on the organisation of research that both the pure science and the applied science departments should be fed by industry with suitable problems and that each industry should examine such problems as arise from time to time and to pass on to universities those which provide suitable subjects. It is pretty generally agreed that there should be close personal contact between workers in universities and workers in industry, and even some interchange of personnel from time to time.

Industrial research laboratories, in addition to their work on the problems of industry, should undertake fundamental work leading to the study of first principles. There can be no doubt whatever that the way to solve any problem is to get down to fundamentals. The

way to get down to fundamentals is to study them experimentally. It very often happens in examining a problem that a gap in fundamental knowledge is revealed; the industrial laboratory should thus be given the freedom to explore this gap, and in so doing would provide a first-class answer to the problem which might well be missed by a laboratory restricted to severely "practical" lines. A combination of industrial laboratories and research associations is obviously desirable. Particular attention is again drawn here to Sir Harold Hartley's recent pamphlet on the subject of research in industry which was discussed in our issue of October 2.

While the expression of the need for more research has been the key-note of 1943, such steps as are immediately practical must not be neglected. One is the pooling of information among British firms so that our natural industries can compete effectively in the export market (and, of course, at home) with the highly organised industrial concerns of other nations. While free exchange of information on research problems is often impossible, a great deal of information which is not highly confidential could and should be pooled. It is understood that the A.B.C.M. is giving attention to this problem. In parenthesis, we would remark that we trust that this pooling of information will also extend to the B.C.P.M.A., since a sound chemical plant industry is essential for the development of a sound chemical industry.

There should be a greater spirit of adventure in assessing market possibilities and in erecting new plant to cater for new markets. This spirit of adventure has characterised all great periods in our history. It is essential, moreover, to go overseas to discuss problems with our customers; we must send overseas not only salesmen but technical experts. An adequate and well-trained technical staff is the basis of any technical industry. How can we attract into the chemical and chemical plant industries the best brains in the country? Only by making our conditions of employment so attractive that the chemical industry provides a worth-while career. That is something worth pondering over.

In entering 1944, industry must ask itself one question in particular: Are we planning adequately for the future? Have we considered what the change from war to peace conditions will entail? Are our Trade Associations so organised and keyed as to prove a spear-head that will not bend or break when industry talks to industry, when industry is sitting at the council table with Government and the Trade Unions, and when British industry discusses world markets with its foreign colleagues? Has each individual firm made plans for research and the development of new products or the rehabilitation of pre-war business? Are we prepared with plans for new plant and new factories? Peace may well come to Europe suddenly in 1944. Are we ready?

New Year Honours

The importance of the contributions which scientists and technologists are making towards the war effort is recognised in the New Year Honours List.

Knights Bachelor

DR. JOHN JACOB FOX is the Government Chemist and is a past-president of the Royal Institute of Chemistry.

PROFESSOR JACK CECIL DRUMMOND is scientific adviser to the Ministry of Food.

MR. WILLIAM PATERSON, chairman of the Paterson Engineering Co., Ltd., was responsible for the original design of the "Anderson" air-raid shelter.

MR. JOHN GIBB NICHOLSON is deputy chairman of Imperial Chemical Industries, Ltd.

MR. GEORGE EDWIN BAILEY holds the position of works director with Metropolitan-Vickers Electrical Co., Ltd.

MR. PHILIP ALLAN WARTER is Controller-General of Factory and Storage Premises, Board of Trade.

MR. FREDERICK CHARLES STEWART is chairman of Messrs. Kelvin, Bottomley & Baird, the well-known firm of instrument makers that markets the K.B.B. Fugitometer.

Other knighthoods go to DR. THOMAS RALPH MERTON, one of the Ministry of Production's three scientific advisers, and to DR. FRANK ENGLEDOW, Professor of Agriculture, Cambridge University.

Other Awards

SIR HAROLD HARTLEY, F.R.S., receives a K.C.V.O.

Two scientists connected with the D.S.I.R. receive the C.B.E. They are DR. W. H. GLANVILLE, Director of Road Research, and MR. W. A. AKERS, a technical director of I.C.I., Ltd., who has been lent to the D.S.I.R. DR. A. N. DRURY, a former member of the Medical Research Council's scientific staff, who has been closely associated with wartime improvement in blood transfusion technique, is similarly honoured, and another recipient of the C.B.E. is LIEUT.-COL. E. BRIGGS, president of the Soap and Candle Trades Employers' Federation.

The O.B.E. is awarded to DR. JOHN EDWIN MACKENZIE, Reader Emeritus in Chemistry at Edinburgh University, for his services as adviser to Indian students at the university. He first became associated with the chemistry department at Edinburgh in 1908, after three years as principal of the Victoria Technical College, Bombay. Other recipients of the O.B.E. are: MR. H. HAWLEY, Government Analyst, of the King Institute of Preventive Medicine, Madras; MR. G. PEACE, Chief Inspector of Explosives in India, and Chief Adviser on Factory A.R.P.; DR. A. JAQUES, R.O.F. superintendent, Ministry of Supply; MR. J. KING, superintending chemist, Government Chemist's Department, seconded to War Office; DR. J. G. KING, director of Gas Research Board, D.S.I.R.; MR. A. F. MACCULLOCH, B.Sc., F.I.C., chief advisory chemist to Director-General, Indian Medical Service; MR. S. W. COLLINS, B.Sc., F.I.C., chief technical officer, Postal Censorship Dept.

The following are included in the list of M.B.E.'s:

MR. J. H. CHALK, works chief engineer, Bakelite, Ltd.; MR. G. EWINS, manager, S.A.A. Department, I.C.I. Metals, Ltd.; MISS N. GARRETT, superintendent of typists, D.S.I.R.; MR. W. MACDONNALD, chill foundry manager, International Alloys, Ltd.; MR. S. MITTON, Keeper, Manchester Branch, Patent Office; DR. D. SHOENBERG, head of extra-mural research team, Royal Society Mond Laboratory, Cambridge; MR. S. E. VAN RYSSEN, R.O.F. superintendent; LIEUT.-COL. HAIDER KHAN, Professor of Chemistry, Aligarth Muslim University; MR. DURAISWAMI NARAYANAMURTI, Dehra Dun Forest Research Institute.

The B.E.M. is awarded to the following: MR. W. J. BROOKS, chargehand, I.C.I., Ltd.; MR. S. CLIPSON, chief superphosphate mixer, Farmers Co., Ltd.; MR. S. DAVIDSON, laboratory worker, Armament Research Department, Ministry of Supply; MR. F. OLIVER, senior foreman of laboratory, R.N. Armament Depot, Plymouth; MR. B. A. PETTIGAN, senior foreman, Peter Brotherhood, Ltd.; MR. A. SIMPSON, head foreman, Worthington Simpson, Ltd.

The Canadian Honours List includes the name of DR. C. H. BEST, co-discoverer of insulin.

Personal Notes

MR. E. HUGH ARMITAGE, managing director of Brown Bayley's Steel Works, Ltd., and chairman of Hoffmann Manufacturing, Ltd., has been appointed a director of Murex, Ltd.

MR. NORMAN ILES has been appointed Director of Plant Progress in the Iron and Steel Control of the Ministry of Supply. He succeeds MR. FRANK PARR, who has been appointed to the post of Steel Commissioner by the Government of India.

The development committee which the Tees-side Chamber of Commerce has just set up includes MR. C. ROBSON, of Ashmore Benson, Pease & Co., Ltd., and MR. F. R. GIBSON, of the Chemical and Insulating Co., Ltd., who represent Stockton and Darlington respectively.

MR. WILLIAM REGINALD HANN, one of the best-known personalities in South Wales coal and coal by-product circles, has retired from active business. Mr. Hann, who was born in 1876, was for many years associated with the Powell Duffryn Steam Coal Company, Ltd., becoming general manager and a director of the company. He was also a director of the National Benzol Company, Ltd., and of several coal concerns.

Obituary

MR. ALEXANDER GORDON OGSTON, who died at Aberdeen on December 28, aged 69, had for many years been associated with Ogston and Tennant, Ltd., soap manufacturers, of Aberdeen and Renfrew.

The death is announced of MR. SAMUEL GORDON LIVERSEDGE, B.Sc., F.I.C., on December 13 at the age of 59. Mr. Gordon was for a long time head of the analytical control laboratory of Messrs. Howards & Sons, Ltd., Ilford.

DR. FRANK LEE PYMAN, D.Sc., Ph.D., F.R.S., F.I.C., director of research, Boots Pure Drug Co., Ltd., Nottingham, died at Radcliffe-on-Trent, Notts, on January 1, aged 61. A full obituary notice will be included in our next issue.

MR. W. GARDNER, a leading authority on gutta percha, died on December 4. He was connected with the Telegraph Construction and Maintenance Co., Ltd., for 45 years, and became manager of the firm's gutta percha and plastics department. He is succeeded in that post by MR. P. W. J. AYERST.

MR. ROBERT TULLOCH, who had been principal teacher of science for over 20 years at Lossiemouth Higher Grade School, Moray, fell into the harbour during the black-out in the early morning of January 1 and was drowned. Mr. Tulloch was a member of Lossiemouth Town Council and had recently been elected Junior Magistrate.

Conditions in, and Some War Problems of, the Heavy Chemical Industry in 1943

by P. PARRISH, F.I.C., F.C.S., M.I.Chem.E., M.I.Gas E., F.I.I.A.

Mr. P. Parrish.

THE chemical industry at the present time is planning. This is very necessary, although it has been seriously suggested that the world is suffering from an epidemic of planning. The Prime Minister led the way in this connection when he suggested that we are "bound, so far as life and strength allow, and without prejudice to our dominating military task, to look ahead to those days which will surely come, when we shall have finally beaten down Satan under our feet, and find ourselves with other great Allies at once the masters and the servants of the future."

The problems of the post-armistice period may be greater and more perplexing than those of the war. Our industries require cheap raw materials, free from unnecessary royalties, and they desire to see a healthy competition in freights, although they recognise that to tie up ships in the estuaries and rivers of this country, as was the case in 1934-36, must ultimately spell disaster to the national economy. Equally, they require cheap railway rates and healthy competition between railways, roads, rivers, and canals. If either or both of the two last are to be brought within the purview of the railways under the ægis of a Transport Board, then industry is entitled to representation on certain of the committees of such board, particularly the Facilities and Rates Committees, so that they can put their case with regard to correct nomenclature or classification of the various goods and confer about the structure of the rates to be charged. Air transport is also a matter that will loom large in the near future, and calls for consideration in any planning scheme.

On the other hand, industrialists desire an indication from the Government of its post-war policy, whether it favours "less government in business," fewer controls, or whether private enterprise, provided it regulates its profits reasonably and adopts management with trained minds, with expert technical knowledge, and at the same time with due regard to human feelings and human aspirations, will be given a fair chance. Some think that there will be rivalry about the type of management—that which is essentially democratic, as opposed to that which is called upon to serve the interests of the big business organisations.

That there will need to be limitations to the size of businesses, and something more than Board of Trade or Foreign Office knowledge of the type of international agreements entered into, is becoming increasingly recognised. The ramifications of international cartels will need to be examined. How far the F.B.I., the banks, and hitherto powerful organisations will be permitted to enjoy their privileges untrammelled is the subject of not infrequent discussion. So far as public utility undertakings are concerned, nationalisation is not favoured, but rather integration, which is calculated to give the best and cheapest service to the consumer, to ensure the best advantages of employment, and to provide a reasonable reward to the many shareholders, small and large.

But post-armistice planning differs little from the planning that every progressive industry has to undertake from its inception onwards. There are few new factors. It may require a more comprehensive understanding of our economy, and more drive, to achieve what is decided upon than is usual in normal development.

Chemical and Metallurgical Achievements

In the earliest war reviews the author attempted to give a picture of the magnitude of the task to be underaken, and last year specific references were made to British output, American achievement, and the prodigious Russian effort. It will be appropriate this year to make reference to the achievement of the chemist and the metallurgist.[1]

Pig-iron production in the U.S.A. was 60 million tons in 1942: this year it is expected that it will reach the formidable aggregate of 70 million tons, involving a coal consumption of 85 million tons. At the same time, the output of steel ingots is expected to rise from 87 million to 97 million tons. Try to conjure what this means in heat and power! Copper, equally, has been in large demand for some, among other, of the following reasons: "A flight of 50 fighter planes shoots away 7 tons of copper. A.

37-mm. anti-aircraft gun uses up to a ton of copper every 20 minues it is in operation. Six hundred lb. of copper go into every medium tank, and a ton into the engines and air-frame of a Flying Fortress. The Signal Corps alone needs 5000 tons of copper every month for radio, telegraphic, and telephonic equipment. An army without copper would be an army without speed, manœuvrability, or fire-power. It would not last a day in battle."[2] But other metals are playing a vital rôle in the war. Tungsten, nickel, manganese, chromium, vanadium, and molybdenum for alloy steels: zinc for brass and die castings, tin for bronze and bearings, aluminium and magnesium for aircraft, lead and mercury for munitions, and silver for electrical equipment, bearings, and solder.

Mineral Resources

Clearly, the nation that controls the world's mineral resources and makes the best and most efficient use of them will win the war. Before this conflict, the British Empire and the United States together controlled probably 75 per cent. of the world's mineral production. It has been estimated[3] that the Axis has improved its position in world mineral resources by the following percentages: iron ore, from 6 to 46 per cent.; steel production capacity, from 20 to 34 per cent.; petrol, from 1 to 7 per cent.; coal, from 27 to 53 per cent.; copper, from 5 to 10 per cent.; lead, from 7 to 22 per cent.; zinc, from 16 to 27 per cent.; tin, from 1 to 72 per cent.; manganese, from 2 to 30 per cent.; chromium, from 3 to 30 per cent., and tungsten, from 6 to 60 per cent. As regards light metals, areas now Axis-controlled produced, in 1940, 54 per cent. of the world's aluminium, 49 per cent. of the bauxite, and two-thirds of the magnesium.[4] Notwithstanding these gains, the industrial war-power of the United Nations exceeded in early 1943 that of the Axis, and by now surpasses it enormously.

It is reported[5] that the U.S. copper production is now breaking all records. Aluminium capacity will be seven times greater than its peace-time average. The capacity of magnesium plants now building will be a hundred times that of the largest year before the war. The biggest single molybdenum mine is in the United States. Zinc, lead, and mercury are more than meeting anticipations in coping with war-time demands, and tungsten, chromium, manganese, antimony, and iron and steel are being produced in record-breaking quantities. The United Nations are fortunate in having the use of Canada's nickel and coal, in the availability of Mexico's lead and antimony, Chile's copper, Bolivia's tin, Peru's vanadium, Brazil's iron, and Venezuela's petroleum. That sheer weight of metal will win the war is undoubted, and that chemists and metallurgists are working strenuously to this end is equally evident.

The year has witnessed further developments in the production of magnesium, and numerous patents dealing with various aspects of the industry have been granted. The recovery of magnesium from brines, which only recently has become so industrially important, appears to have claimed the attention of the majority of investigators, both in this country and in the U.S.A. This is not surprising, when it is realised that the supply of magnesium from marine brines is practically inexhaustible (one cubic mile of average sea-water contains over four million tons of magnesium), and almost universally available. According to Dr. Desch,[6] the average magnesium content of sea-water is about 0.14 per cent., equivalent to a theoretical yield of 0.34 per cent. of the hydroxide. In some parts of the world, however, concentrated brines are found, which contain a much higher proportion of magnesium salts. For example, the Michigan brines used by the Dow Chemical Co., have an equivalent magnesium content of one part per hundred.

Sea-Water Magnesium

The sea-water process, although simple in principle, involves much ingenuity in its industrial operation, on account of the necessity of treating large volumes of water. Generally, pre-treatment with lime is necessary, in order to remove bicarbonate and sulphate before the magnesium is precipitated by treatment with pure lime or calcined dolomite. The advantages of using dolomites are: (i) the yield from a given quantity of water is almost doubled, and (ii) the magnesia particles, by acting as nuclei for precipitation, affect the physical condition of the precipitate. Local availability, however, is usually the deciding factor in the choice of the precipitant. The Dow Chemical Co., at its Texas plant, uses pure lime prepared by calcining oyster shells, of which large deposits exist near the source of the brine. The plant for precipitation, comprising flocculators, thickeners, and vacuum filters, calls for special design, since many factors influence the physical character of the precipitate, and, consequently, the rate of throughput. Methods of treatment of the precipitated magnesium hydroxide vary somewhat, according to local circumstances, or the purpose for which the magnesia is required. The filter cake may be calcined in rotary kilns, a fully calcined material being provided where magnesium is to be produced by thermal reduction methods, or a more reactive caustic magnesia prepared by the electrolytic process. On the other hand, the filter cake may be treated directly with hydrochloric acid, as in the Dow plant, where the hydrochloric acid is produced by burning natural

gas in the chlorine resulting from the subsequent electrolysis.

The following summary of recent patent literature gives some indication not so much of the trend of development, as of the attention to detail that the process demands. In order to minimise the contamination of the precipitated magnesium hydrate with calcium carbonate, Messrs. Ocean Salts (Products), Ltd., propose[7] to carry out the precipitation in the presence of not more than five parts per million of a protective colloid capable of holding calcium carbonate in molecular or colloidal solution. Impure magnesium hydrate contaminated with calcium carbonate (resulting from the pre-treatment of brines) may be calcined, the product ground with water, and the slurry added to sea-water freed from carbonic acid. The precipitated magnesia is then dried and calcined to produce pure magnesium oxide[8]; or the uncalcined slurry may be: (a) saturated with CO_2 under pressure to convert most of the magnesium to magnesium bicarbonate; (b) filtered and treated with a small amount of pure hydrate and crystalline carbonate to precipitate the remaining calcium; (c) again filtered; and (d) finally treated with more hydrate to precipitate the magnesium as basic carbonate.[9]

According to Marine Magnesia Products Corporation,[10] filtrate resulting from the pre-treatment should be de-aerated (at 18°-22°C., under 15-26 in. mercury pressure), by cascading over grids and baffles prior to the final precipitation of the hydrate. This treatment is said to result in a sensible increase in the rate of settling of the precipitate. Another method of accelerating settling[11] is to pre-treat sea-water, sterilised with chlorine, with a slight excess of calcium hydrate, and to add a proportion of this "activated" precipitate to subsequent batches.

Aluminium

One method of producing aluminium from clay or shale consists in mixing the clay with ammonium sulphate and sintering the mixture, whereby ammonia is evolved and the alumina rendered soluble in the form of ammonia-alum. Important modifications in this process have recently been described in a series of patents by English Clays, Lovering, Pochin & Co., Ltd., R. J. Davies, H. O. Dering, and T. W. Parker.[12] The complete process involves the following operations: (a) the sintering of a mixture of clay in ammonium sulphate under such conditions that the alumina is converted to ammonia-alum, and the ammonia evolved under its own vapour pressure; (b) extracting the sintered mass in hot ammonium sulphate solution and separating the undissolved solids; (c) cooling the solution and crystallising practically iron-free ammonia-alum; and (d) passing a solution of ammonium sulphate containing absorbed ammonia through a stationary mass of the crystals to convert the ammonia-alum to aluminium hydrate and ammonium sulphate. The aluminium hydrate may be dried *in situ* by passing hot air through the mass.

Ammonium sulphate, which is re-cycled for sintering a fresh charge of clay, is recovered by evaporation, the solutions being maintained at maximum concentration in order to reduce such evaporation to a minimum. This is accomplished by the re-use of dilute liquors and by carrying out the reaction between the ammonia and ammonia-alum in such a manner as to increase the concentration of the stronger liquors. A concentrated solution of ammonium sulphate, saturated with aluminium sulphate, is used for removing iron-containing mother liquor from the alum crystals, since ammonia-alum is only slightly soluble at normal temperatures in saturated ammonium sulphate solutions.

Another method of extracting aluminium from clays and shales, due to J. C. Stein and J. H. Hyslop,[13] involves the extraction of the roasted clay with sulphuric acid, and treatment of the resulting solution with calcium carbonate. The mixture of calcium sulphate and aluminium hydrate so formed is then mixed with clay, calcium carbonate, and sodium carbonate in the proportions required to form $2CaO, SiO_2, NaAlO_2$ as a clinker on calcining at 900°-1300°C. The clinker is finally leached with water and the aluminium precipitated from the solution in the usual manner.

Alumina may also be prepared from clay electrolytically according to a process proposed by G. T. Antonoff.[14] The ground clay in aqueous suspension is continuously electrolysed in the anode chamber of a cell provided with a permeable rubber membrane and lead or carbon electrodes, in the presence of sodium fluoride and sulphuric acid or sodium sulphate. Aluminium hydrate is precipitated by CO_2 from the cathode liquors and the sodium carbonate solution is returned to the anode chamber, from which silica is continuously removed by filtration.

Molybdenum

The most important consumer of molybdenum is the iron and steel industry. The ability of molybdenum alloys to resist abrasion, fatigue failure, and corrosion is now well-known, although it is in the past ten years that interest in this metal has become so widespread. This is shown by the records of world production, which increased from about 22,000 lb. in 1900 to between 35 and 40 million lb. in 1943.[15] Only four molybdenum-bearing ores are common, namely, molybdenite, wolfenite, powelite, and molybdite. Of these, over 99 per cent. of the world production and known reserves are in the form of molybdenite, which is a

relatively common mineral, in spite of the usual reference to molybdenum as one of the rare elements. In recent years a substantial production of the metal has come from by-product molybdenite out of the copper mines in the U.S.A., Mexico, and South America, several million pounds of the metal being produced annually from this source.

It is now reported[16] that as a result of the development of a large deposit of molybdenite in Amos, Northern Quebec, Canada will shortly be able to produce the metal at the rate of about two million lb. annually. During the last war Canada became the leading producer of molybdenum, but most of the Canadian deposits are of low grade, and were abandoned when richer sources of supply were developed in Colorado, U.S.A. Some of these richer properties have, however, been re-examined recently, and several have been taken over and are now operated by the War-Time Metal Corporation.

Synthetic Nitrogen

That the world's nitrogen fixation industry has increased very considerably is known; but to what precise extent will not be revealed until after the war. In the United Kingdom[17] there are seven nitrogen fixation factories—four Government and three privately owned. As is known, the ammonia industry has been highly organised, and a close co-operation has existed between the Government, the producer, and the consumer for some years. This admitted of the immediate operation of Government control on the outbreak of war, for the planning and maintenance of production and distribution of these commodities, so vital to the manufacture of explosives and fertilisers.

As much as 75 per cent. of the annual consumption of nitrogen fertilisers is in the form of ammonium sulphate. A large proportion of the latter is manufactured from home-produced synthetic ammonia, the balance being produced as a by-product of the gas and coking industry. Nitrogen fertilisers are sold principally to the farmers, as before the war, through the medium of several thousands of agricultural merchants. Statutory power was taken to register producers and merchants, who alone were permitted to supply, thus preventing speculation. Chilean nitrate of soda is imported on Government account, and is distributed by the Nitrate Corporation of Chile, Ltd., as agents for the Ministry of Supply, on instructions from the Control.

In the United States there has been an important expansion in the production of synthetic nitrogen, and Canada is manufacturing large quantities of ammonium nitrate. It is felt that the pre-war European Nitrogen Cartel will need to be expanded so as to embrace Canada and the United States, and the view has been expressed by Sir Robert Robinson, some months ago, to the Parliamentary and Scientific Committee, that German and Italian nitrogen-fixation plants should be dismantled, and that these Axis nations should, besides having their "teeth drawn," be made to contribute towards the solution of one of the perplexing economic problems which their policy of aggression has served to create. And should not Japan be similarly treated? An American view in this connection may show the shape of things to come. Nitrogen-fixation factories in the natural-gas fields, on or near the Gulf Coast, would have the advantage of low fuel requirements, and low-cost hydrogen from natural gas. Indeed, synthetic ammonia might be produced at a cost low enough to admit of the acidulation of phosphate rock with nitric acid, where phosphate rock and potash were available at the synthetic ammonia factory at a minimum cost for transportation, and whence the product would proceed by low-cost water transportation to the consuming areas.

Rubber—Natural and Synthetic

In America the view is held that the future of rubber depends on the outcome of scientific competition between the industrial research laboratories and the agricultural experimental stations. "No development holds more potent possibilities than the race between the chemist and the agricultural scientist to supply the expanding needs of the machinery age for rubber, and to supply it cheaply and abundantly." The latter is the expression of Earl N. Bressman,[18] Director of the Inter-American Institute of Agricultural Science, newly-established at Turrialba, in Costa Rica.

Doubt has been expressed whether synthetic rubber made from alcohol or petroleum by polymerisation in a State factory, paying high wages, taxes, overheads, etc., can compete with the production of natural rubber, which is regarded as an ideal small-family industry. The American view is that it is in the interests of rubber consumers to see that the rubber of the future emanates from a really cheap source. It is said that with fully-matured plantations of high-yielding trees to produce rubber, the price should be 10 cents (say 5d.) per lb., or less. It has been urged that "plantations," not "plants," and "trees," not "processes," represents the solution of the problem. Opposed to the above view is the following: "In five years a rubber tree will be as foolish, economically, as a wild strawberry .... I talked of this recently with the erstwhile manager of one of the leading rubber plantations of the Far East. Somewhat to my surprise, he agreed. He said: 'On the basis of what we know now, I can produce more rubber with three hundred men in a factory than I can produce with ten thousand men on a plantation.'[19] "

It has, however, been observed that

natural rubber can be improved by incorporating certain ingredients (*e.g.*, products made by destructive distillation of natural rubber itself), to enable it to recapture even the special-purpose applications for which the synthetic product is admittedly superior. On the contrary, a Rubber Research director points out that improvements in the technology of polymerisation would make it possible to produce at will synthetic rubbers that could completely displace the natural product. It is believed that if technology and private enterprise are left to operate unhindered, to work out this problem in their own way, one can at least be certain that cheaper rubber products will be available than ever before, whether of natural or synthetic origin, or both.

Of the total annual world supply[20] of 1,400,000 tons of raw rubber, 1,100,000 tons was of British-Malayan or Dutch East Indian origin, the loss of which source of supply by Japanese occupation has led to the most rigid control. To replace this loss, intensive development of the production of both wild and plantation rubber in Africa, South America, and Ceylon, is being pursued under expert guidance. Every form of rubber and rubber goods has progressively been brought within the control of the Ministry. The materials covered include crude rubber, liquid latex, balata, gutta percha, waste and reclaimed rubber, and synthetic rubber.

Hydrochloric Acid

Reference was made last year to a modified type of Mannheim furnace for the production of salt cake and hydrochloric acid. Two or three such furnaces were erected, but trouble has, unfortunately, been experienced with corrosion and the breaking of the arms. It is wrong in principle to introduce cold salt and sulphuric acid to a mechanical furnace, the arms and rabbles of which have attained a temperature of 600°C. or more.

There are two stages in salt-cake production, namely:

(1) $NaCl + H_2SO_4 = NaHSO_4 + HCl$;
(2) $NaHSO_4 + NaCl = Na_2SO_4 + HCl$.

To ensure a marketable product, the salt cake should be porous and friable, rather than fused: thus, the second reaction should be effected at a temperature below the melting-point (843°C.) of salt cake.

In the United States the Laury furnace has been adopted (*see* Fig. 1). This consists of a horizontal rotating cylinder, arranged in two parts and provided at one end with a combustion chamber, oil-fired. This chamber is disposed on a bogey, which can be removed at will. The charge enters the small end, which is lined with chilled cast-iron plates, and carries a loose cage made of steel rolls. The first stage of the reaction is effected here, or if the charge is nitre cake and salt, this chamber serves to grind and mix the charge and in it the reaction is initiated. Between the grinding chamber and the hot chamber is a cast-iron plate with a hole in the centre for the products of combustion, and the radial slots near the periphery serve to distribute the ground material to the hot chamber, where the second stage of the reaction is completed.

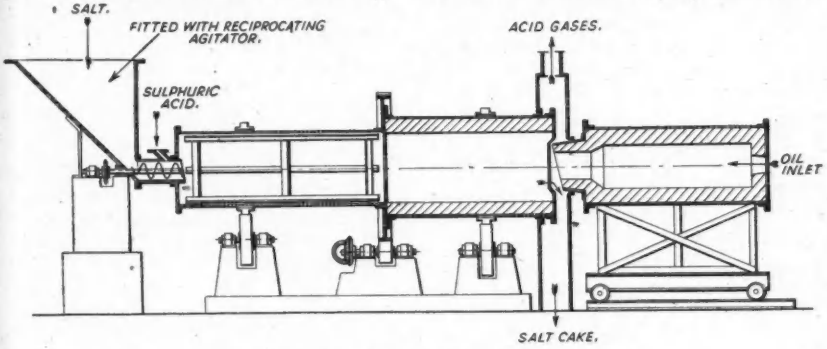

Fig. 1. Laury mechanical salt-cake furnace.

The furnace discharges continuously into a steel housing. Fusion of the product (salt cake) can be avoided by proper control of the temperature conditions, which is not difficult where oil-firing is involved. This equipment is an excellent one, from the point of view of the production of salt cake, but great care needs to be taken to avoid dilution of the hydrochloric acid gases. In any case, an adequate cooler is a necessity, in order to remove the sensible heat, and to reach dew-point. Moreover, considerable quantities of weak hydrochloric acid should be circulated in a tower at the end of the system, in order to ensure efficient recovery of the hydrochloric acid gas.

In view of the growing importance of an-

hydrous hydrogen chloride in organic syntheses, notably in the preparation of chloroprene and chloroethylene, the contributions of A. H. Maude are of particular interest. In a paper read to the American Institute of Chemical Engineers, this author deals with the synthetic production of hydrogen chloride by the combustion of chlorine in hydrogen. The usual plant-constructional material is fused silica, but, if precautions are taken to avoid dew formation, copper, and even cast iron, can be used in certain parts of the plant. When the gas is cooled below its dewpoint, however, tantalum or silica contact surfaces are essential. Ignition of the gases is best effected by the use of a retractable air-hydrogen blow-torch, although improvements on the method are still being sought. The method usually adopted for the concentration of hydrochloric acid is absorption in water, followed by distillation and condensation of the water from the vapours and subsequent drying of the hydrochloric acid by passage through sulphuric acid. An alternative method consists in absorbing the gas with a metallic salt, from which it may be removed later by the application of heat. Among the salts considered are copper and lead sulphates. The use of these and other salts is proposed by the same author[21] as a means of transport and storage of anhydrous hydrogen chloride. For example, porous clay (1 part) may be impregnated with copper sulphate (4 parts), dehydrated at 300°-350°C. and briquetted with sodium silicate. A suitable container for the material comprises an iron or steel cylinder, provided with a steam coil for regeneration. Such a system will absorb and store hydrochloric acid to the extent of 30 per cent. of its total weight.

Sulphuric Acid

There is reason to believe that over 2 million tons per annum of sulphuric acid is being produced in this country at the present time. The Sulphuric Acid Control[22] is concerned with the general supervision, manufacture, and distribution of this mineral acid: its functions include the importation, re-sale, and distribution of imported raw materials, sulphur and pyrites, and the distribution of sulphuric acid arising as a by-product of zinc smelting. No raw material is imported on private account. The Control is also concerned in the use of home-produced raw materials for sulphuric acid, namely, spent oxide, anhydrite, and pyrites recovered from coal waste.

It is learned that the whole of the pyrites is obtained from Spain and the whole of the sulphur from the U.S.A. under lend-lease. The cinders resulting from the burning of the pyrites are a useful form of iron ore, and are disposed of to the Iron and Steel Control. The prices of imported raw materials are stabilised and a levy charge per ton of acid is payable by all producers of this mineral acid. This levy is collected by the Control, and provides a fund to meet losses on the sale of imported raw materials and certain other contingencies.

The production of spent oxide in the United Kingdom has reached the commendable figure of about 220,000 tons per annum (say, 100,000 tons of sulphur), against a pre-war figure of 150,000 tons. It is believed that something of the order of 120,000 tons of 70 per cent. acid is being made in this country from anhydrite. Anhydrite is ground (60 per cent. passing 100 mesh), and 40 parts mixed with 10 parts of sand and 14 parts of kaolin (some firms use special clay). The latter ingredients are carefully mixed and fed to a rotary furnace, 162 ft. 6 in. long and 10 ft. diameter, and producer gas is introduced with a controlled amount of heated secondary air, so that a satisfactory cement clinker is formed, and at the same time a burner gas containing 6 per cent. SO_2 is obtained. One ton of monohydrate sulphuric acid requires 1.7-1.75 ton of anhydrite and yields a cement clinker of the order of 1.05-1.10 ton. Thus, the efficiency, from the sulphur point of view, is about 80 per cent.

Practice in Germany

The author and Mr. Andrew M. Fairlie—the American sulphuric acid expert—had the privilege of inspecting the I. G. Farben's plant, manufacturing contact acid from anhydrite, at Leverkusen in 1930. It was clear then that an economic process had been established, and that technical details had been gradually evolved so that an optimum yield of sulphur dioxide of suitable concentration for catalytic oxidation to SO_3 had been attained, and the conversion efficiency, using vanadium oxide as a catalyst, was of a reasonably satisfactory order. One learns [23] that an improvement of the Leverkusen process has been introduced at the I. G. Farben's Wolfen plant, and that 80,000 tons of sulphuric acid per year are being produced there at the present time. Gypsum is also being used to provide the sulphate radical at the I. G. Farben's huge Leuna works in Saxony.

About 10,000 tons of coal pyrites per year are being used in the manufacture of sulphuric acid to-day. The Ministry of Supply (Sulphuric Acid Control) instal and operate the processes and sell alike the pyrites and the separated coal. Three processes of treatment have been developed: one relates to crushing, screening, and cleaning the coal waste, which presumably involves the use of Wilfley tables; in the second air separation is the governing principle; the third is an elutriation method, representing an adapta-

tion of the applied principles of the Baum washer.

It has been found that the economic optimum content of sulphur in coal pyrites is 44-45 per cent. Generally speaking, the particle side of the coal pyrites is less than that of Spanish pyrites, and as the rate of combustion is greater the finer the particle size, in order to avoid inconvenience due to excessive temperature in the top shelves of the mechanical burners employed, it is customary to mix a predetermined percentage of Spanish pyrites to arrest a too rapid combustion.

Research Opportunities

It is wrong to assume that no opportunity exists for research in the sulphuric acid industry. At the present time a large number of manufacturers take the line of least resistance, and manufacture sulphuric acid from sulphur. This is a relatively simple process, capable of easy control, and possessing flexibility as regards production, if one knows (a) how to utilise chamber space to the best possible advantage, and (b) how to apportion the Glover and Gay-Lussac towers suitably. But the manufacture of sulphuric acid from anhydrite or spent oxide with H_2S-containing gases, or even with pyrites, is a more difficult problem. Yet the possibilities for the production of cheap sulphuric acid are more alluring, because the difference in the unit price of the respective qualities of sulphur leaves a margin which can be profitably exploited, given correct design and ordered control.

One of the problems facing chemical engineers, where spent oxide is burned in mechanical burners, is the design of a foolproof electrostatic precipitator, which will operate without interruption. The average moisture content of spent oxide may be of the order of 8-10 per cent., taking the cellulosic water into consideration. This means that the burner gases contain much more steam than obtains in the combustion of pyrites or sulphur. Obviously, the dewpoint of the burner gases is influenced by the presence of large volumes of steam, and it is here that there is need for contemplating a modification of design to ensure that the insulators and positive electrodes are maintained free from deposit. Much centres around the correct combustion of the spent oxide and the correct admission of air, so as to avoid sublimation.

One's attention is drawn from time to time to newly-constructed Glover towers of unsuitable dimensions. The old formula for Glover towers still holds good. The superficial area at the point where the lining is 9 in. thick should be 4.0 to 4.25 sq. ft. per ton of monohydrate sulphuric acid to be made per day. To erect unwieldy Glover towers where no extension of burning capacity is contemplated, is to be deprecated,

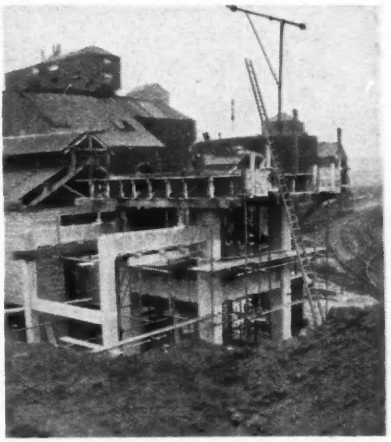

Fig. 2. Substructure of Glover tower.

because they materially disorganise working, and the technical and economic results are disconcerting in the extreme. Moreover, the manager or chemist in charge of the plant can have no peace of mind. Glover towers are built of varying heights, ranging from 27 ft. 6 in. to 40 ft. Everything depends on (a) the nature of the raw material to be burned, (b) the type of burner to be used, (c) the size of the dust chamber or electrostatic precipitator, (d) the extent to which denitration within the tower is expected, and (e) the effective free space and scrubbing surface afforded by the packing medium.

The function of the Glover tower may be regarded as threefold. Primarily, this tower serves as a denitrator, and this should be the governing consideration of design; secondly, it acts as a concentrator of chamber acid; and thirdly, to a limited extent, it serves as a producer of sulphuric acid, especially if the nitrose fed to it is of relatively large volume, and of reasonably high nitrosity.

In so far as a Glover tower serves as a maker of acid, it does certainly influence its capacity to denitrate and concentrate, but the latter functions can be maintained at the same time as production is ensured, provided that a taller tower, say, one 40 ft. high, as against 30 ft., is installed. Under such conditions one should conserve, as far as possible, the sensible heat of the burner gases, that is the temperature entering the Glover tower should be of the order of, say, 650°C. It is wrong, however, to admit burner gases to a Glover tower having a temperature of 825°-850° C., unless special precautions have been taken. It is often overlooked that the opera-

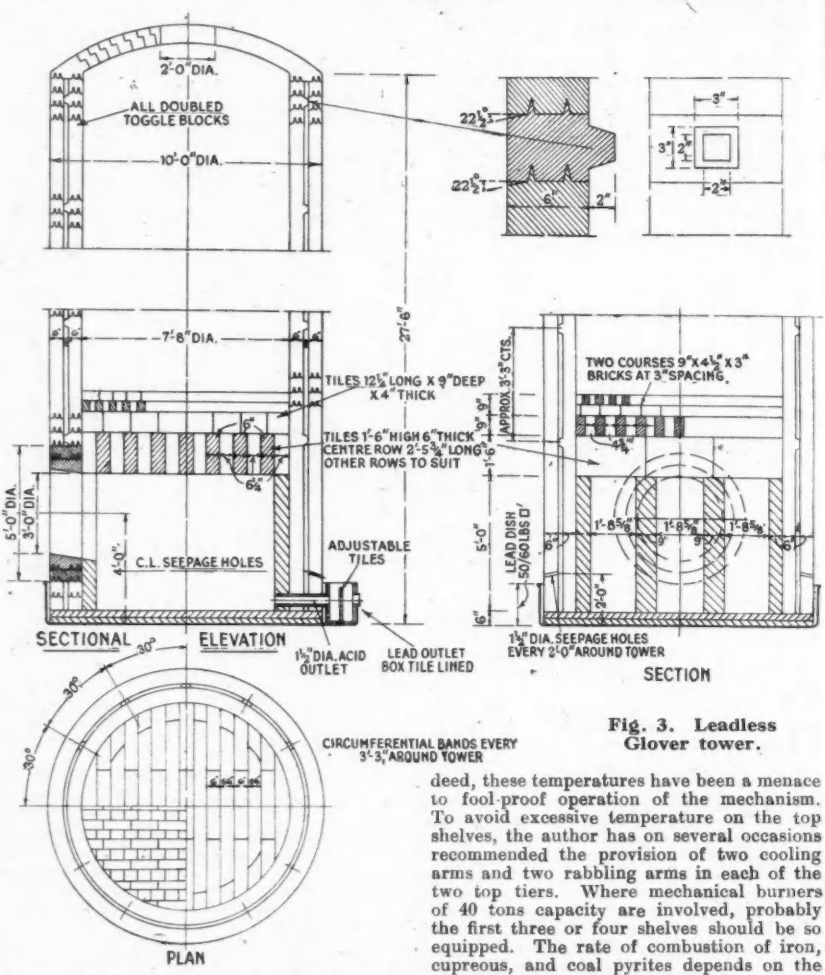

Fig. 3. Leadless Glover tower.

tion and efficiency of Gay-Lussac towers affect the working of a Glover tower.

The capacity of mechanical pyrites burners has yet to be defined in terms of the particle size of the sulphur material that is being burnt: indeed, it may be necessary to introduce additional equipment where the particle size of the sulphur material is appreciably less than that to which manufacturers have hitherto been accustomed. Pyrites of finer particle size than normally have reached this country during the war, and difficulty has been experienced because of the increased rate of combustion and the higher temperatures that have resulted. Indeed, these temperatures have been a menace to fool-proof operation of the mechanism. To avoid excessive temperature on the top shelves, the author has on several occasions recommended the provision of two cooling arms and two rabbling arms in each of the two top tiers. Where mechanical burners of 40 tons capacity are involved, probably the first three or four shelves should be so equipped. The rate of combustion of iron, cupreous, and coal pyrites depends on the particle size, and means for relating such particle size to tons-per-day capacity for various sizes of mechanical burners must certainly be studied.

Apart from normal problems in the sulphuric acid industry, there are those which relate to extensions of plant where units of sulphuric acid chambers exist. Clearly, where piling is involved to obtain a satisfactory foundation, this should be done without causing vibration, otherwise the autogenous seams of the adjacent sulphuric acid chambers will be adversely affected. The system of piling which ensures freedom from vibration is the Franki type of pile. This is a

reinforced pile, cast *in situ* by means of steel casings, constituted of short sections which are superimposed, and are hand- or mechanically-bored to the required depth. When the desired depth is reached the bottom is sealed and water (if any) pumped out. A batch of concrete is then placed in the tube and rammed by means of a hammer working inside the tube. This process is continued until no further compression is possible, thus forming an enlarged base on the pile. The shaft above the enlarged base is made by depositing successive charges of concrete and ramming them with a hammer as the tube is withdrawn, thus producing a rough column which ensures the maximum skin friction, and is larger than the outside diameter of the tube. Fig. 2 represents the substructure of a Glover tower, where the piling was undertaken in the above manner.

Another novel problem with which the sulphuric acid industry is faced at the present time is the construction of leadless Glover and Gay-Lussac towers. Fig. 3 shows the design of a leadless Glover tower, from which it will be seen that there is provided an annulus dividing the inner and outer walls. The underlying idea is to ensure that any seepage of acid through the inner wall will be led to the dish of the Glover tower, thus maintaining a perfectly tight exterior. At certain intervals (about 3 ft. centres), the tiles of the inner wall are provided with tongues, so as to give stability to the circumferential bracing. Essentials in the construction of a leadless Glover tower are (a) adequate provision for expansion, and (b) security of bracing at the grill, where the maximum pressure is exerted by the packing.

Acid-Resisting Cements

Acid-resisting cements of the type containing an inert aggregate and sodium silicate are not altogether satisfactory in practice, where joints in contact with acid are required to withstand appreciable tensile and sheer stresses. Cement made by mixing acid-resisting brickdust with sodium silicate and using sodium silicofluoride as accelerator, may show excellent properties after standing in air for two or three days, but may fail completely after prolonged immersion in relatively weak acid. Much depends, of course, on the grading of the aggregate and the use of silicate solution of the correct sodium-silica ratio. But, generally speaking, the usefulness of cements of the water-soluble silicate type is limited to constructions where joints are not subjected to mechanical strains.

A recent discovery of R. Ward and Imperial Chemical Industries, Ltd., however, promises to minimise such limitations and at the same time to improve resistance to acid penetration. These desirable qualities are obtained by using a small quantity of one of the lower alkyl esters of the fatty acids for accelerating the setting of the cement. In the example given in the patent specification,[24] 4 lb. of acid-resisting brick-dust (75 per cent. through 240 B.S screen) were gauged with one pint of sodium silicate solution of 70°Tw., using 120 c.c. of ethyl acetate as accelerator. Test pieces were made by applying the mixture as a 1/16-in. joint between pairs of bricks. After standing for 24 hours, one test piece was subjected to a tensile strain applied at right-angles to the joint, when a force of 129 lb./sq. in. was required to break the joint. Similar test pieces were immersed in 77 per cent. sulphuric acid for three days, five days, and three months respectively, after which periods the joints failed at 73, 89, and 87 lb./sq. in., when tested in a similar manner. For purposes of comparison the tests were repeated exactly, except that 2.5 per cent. by weight of sodium silicofluoride was substituted for the ethyl acetate. Although the air-dried joint showed a tensile strength of 75 lb./sq. in., the remaining test pieces failed to hold the bricks together after immersion in 77 per cent. sulphuric acid for 48 hours. The foregoing gives an indication of some current problems, but that there is a need for fundamental research in the sulphuric acid industry, both as regards manufacture, application, and utilisation of waste acids does not call for elaboration.

Fig. 4 represents a general arrangement of a Gaillard-Parrish plant capable of producing 15,000 tons of 70 per cent. sulphuric acid per year. It contemplates the provision of two mechanical spent-oxide burners, with a fuelless concentrator, intended to produce C.O.V. by reducing the sensible heat of the burner gases to reasonable limits—say about 600°C. Hot Glover acid at 160°C. is led by a silicon iron pipe and valve direct to the fuelless concentrator, so that advantage is taken of its sensible heat. There are six hexagonal chambers of the Gaillard-Parrish type. This allows of easy construction as regards the leadwork, and hexagonal chambers possess practically all the advantages of a circular chamber. With covered tower chambers such as are indicated, the length of life is of the order of 15-16 years. In Chile several decagonal tower chambers have been erected, 30 ft. diameter by 60 ft. high, and, operating on the liquid-phase system, these give a degree of control unapproached by any other method.

Chemical Products for Agriculture

No industry has expanded more than the agricultural industry during the present war, and on every hand there are evidences of its increasing significance. Not only are we concerned with the production of greater quantities of food, but, with the advent of the armistice, we shall have new and urgent

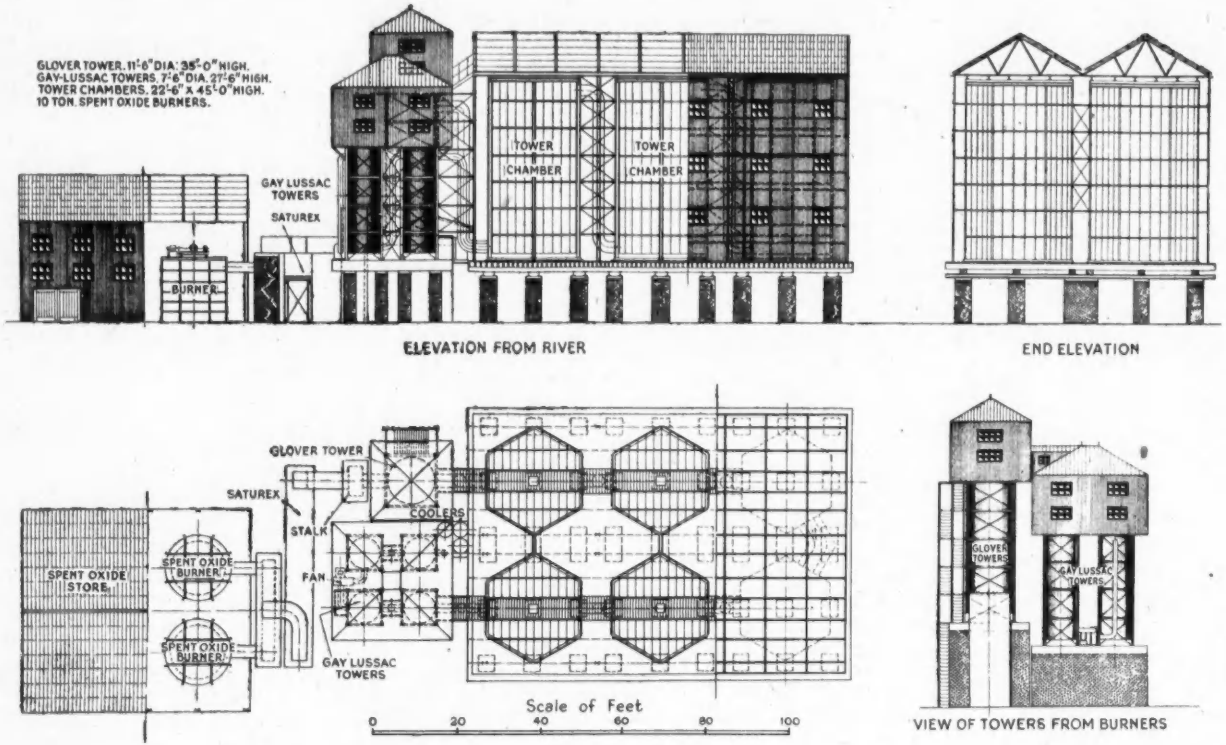

Fig. 4. Gaillard-Parrish sulphuric acid plant, 42 tons per day capacity.

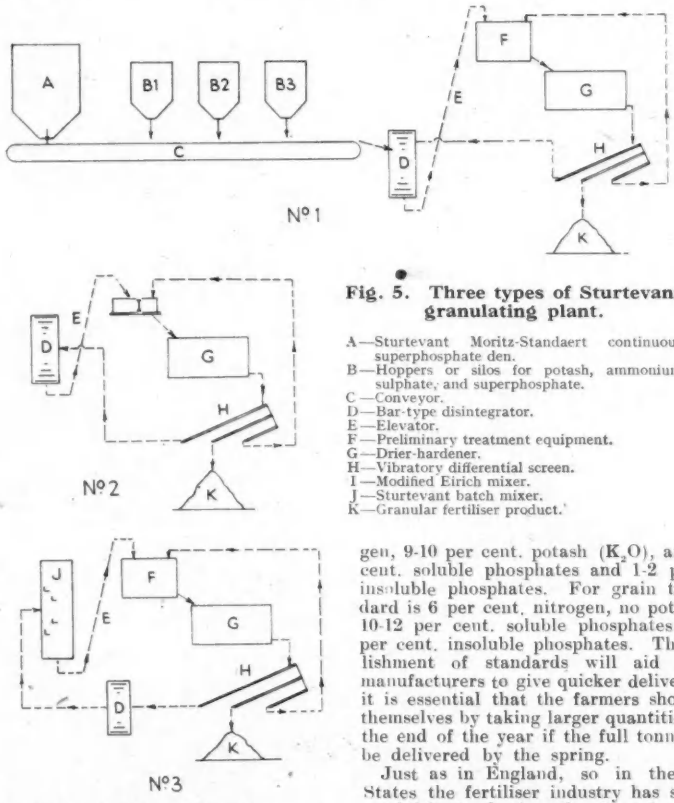

Fig. 5. Three types of Sturtevant granulating plant.

A—Sturtevant Moritz-Standaert continuous superphosphate den.
B—Hoppers or silos for potash, ammonium sulphate, and superphosphate.
C—Conveyor.
D—Bar-type disintegrator.
E—Elevator.
F—Preliminary treatment equipment.
G—Drier-hardener.
H—Vibratory differential screen.
I—Modified Eirich mixer.
J—Sturtevant batch mixer.
K—Granular fertiliser product.

problems relating to the feeding of enemy-occupied countries. Little wonder, therefore, that this country and America find their needs for agricultural chemicals increasing. Some indication of what is needed in the shape of phosphatic fertilisers can be gleaned from the statement made by Dr. Yates, of Rothamsted. He said: "In monetary terms alone, potential losses of crops in England and Wales from serious phosphate deficiency at the present time are of the order of five million to ten million pounds. A survey has shown that if an additional 10 per cent. of land receives phosphate, this will result in a gain in crop yield valued at £500,000 to £1,000,000 in a single year."[25]

This increasing demand for chemical fertilisers has rendered necessary not only the control of the quantity, but the type permitted for specific crops. Standard compound fertilisers have been introduced to Scotland.[26] For potatoes the standard grade is one containing 6-7 per cent. nitrogen, 9-10 per cent. potash (K_2O), and 8 per cent. soluble phosphates and 1-2 per cent. insoluble phosphates. For grain the standard is 6 per cent. nitrogen, no potash, and 10-12 per cent. soluble phosphates and 1-2 per cent. insoluble phosphates. This establishment of standards will aid fertiliser manufacturers to give quicker deliveries, but it is essential that the farmers should help themselves by taking larger quantities before the end of the year if the full tonnage is to be delivered by the spring.

Just as in England, so in the United States the fertiliser industry has sought to establish standard grades for mixed fertilisers. Indeed, America invoked spokesmen and representatives of the industry to speak in all parts of the States. As a result, recommendations were drafted relating to the most desirable grades for mixed fertilisers for each area. The results were considered officially, and a set of required "Grade Standards" was established. It is expected that this will lead to a substantial economy, because of the fewer grades to be marketed in any given area.

Other innovations[27] are the use of tear gas (chlorpicrin) for horticultural soil treatment, which it is claimed is only slightly less effective than steam sterilisation. A new synthetic insecticide in the form of a greyish powder is said to be more efficient than derris against the turnip flea-beetle. Phenothiazine has been employed as a vermicide for sheep, with a reputed increase in weight of about 5 lb. National Growmore Fertiliser was introduced late in 1942, based on

7 per cent. each nitrogen, phosphate (P_2O_5), and potash (K_2O), and has been adopted with enthusiasm.

Last year's observations about the granulation of superphosphate and compound fertilisers created unusual interest, and the author was the recipient of much private correspondence on this subject. There can be hardly any doubt that a granular fertiliser possesses advantages over an amorphous and sticky product. A granular fertiliser admits of application by drills and strip or other formation. Experiments, both in Sweden and America, reveal that it is not only desirable to place the fertiliser at a slight distance from the seeds in strip formation, but that the efficiency of utilisation of the fertiliser is increased materially in consequence. Probably the crust of the granule retards ready attack by lime, or iron, or alumina, and a little initial resistance to solution by water may be a not undesirable property in any fertiliser—single or compound. Too often a solution of soluble constituents seeps through the soil beyond the zone of availability, and is lost. Questions often asked recently have been: "How is granulation effected?" and "Is one limited to one specific process or can one exercise some choice?"

In order to economise words, Fig. 5 has been prepared, to illustrate three types of Sturtevant granulating plant. No. 1 scheme shows diagrammatically a dual arrangement, where freshly-made calcium superphosphate from den A can be granulated alone by passing the hot product through a disintegrator D, treating it afterwards with steam and bentonite in a special preliminary treatment vessel F, after which it is passed to the drier-hardener G, from which it is discharged to a differential screen, so that the coarse granules and fines can be returned suitably to their respective points for re-treatment. Working with a differential screen in this way, granules of singularly uniform size can be obtained. This identical plant can be used for the manufacture of granulated compound fertilisers of any analysis by reducing the feed of calcium superphosphate to the conveyor, and by introducing, in addition, from their respective silos, potash salts and sulphate of ammonia in suitable proportions. Breakage and mixing take place in a disintegrator, and the material should preferably pass about 1/16 in. screen on introduction to the preliminary treatment vessel, where the same unit operations are undertaken as have been described earlier.

Scheme 2 is intended to apply to the manufacture of compound fertilisers, and is a simple form of plant, in which the ingredients are fed to a disintegrator to be broken and mixed. They then pass to an Eirich mixer, where they are suitably moistened, with water which admits of the best possible distribution, and to which

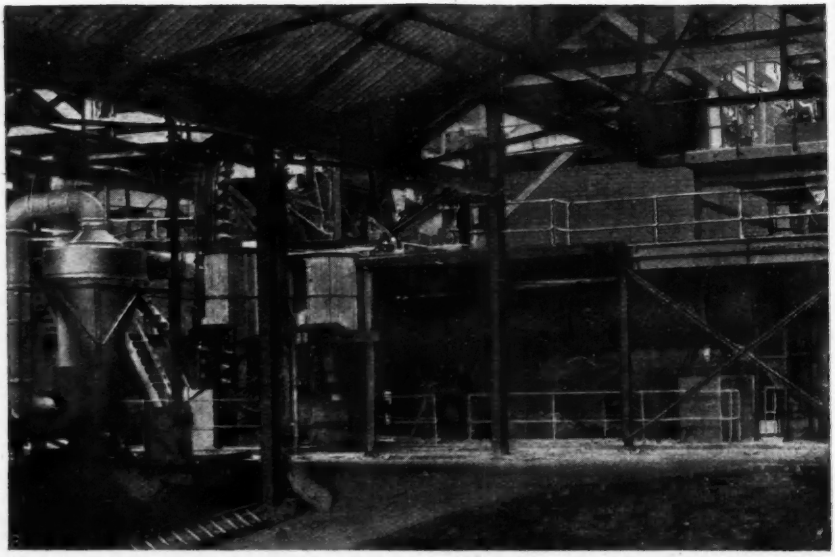

Fig. 6. General arrangement of a 5-tons-per-hour Sturtevant granulating plant for superphosphates and compound manures.

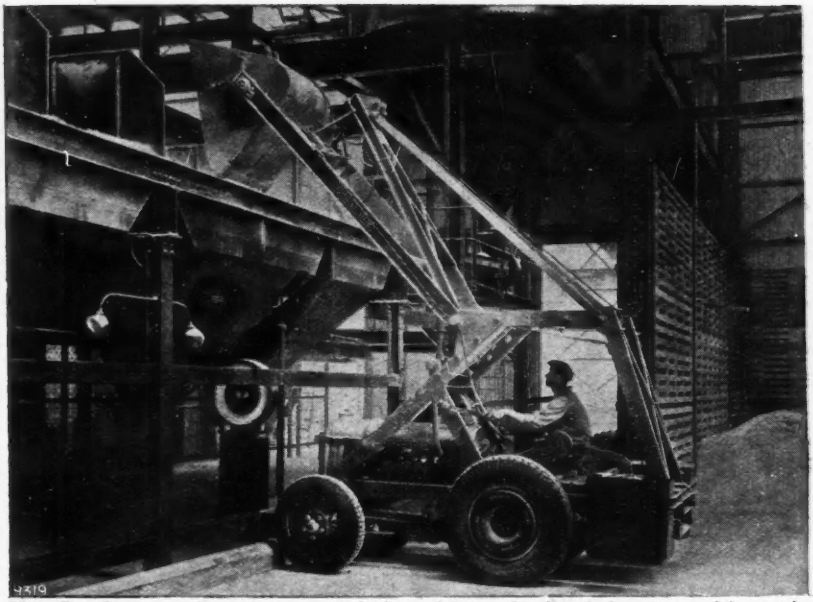

Fig. 7. Compound manure granulating plant: the batch hoppers with semi-automatic weighers.

bentonite can be added for accelerating granulation. After a pre-determined mixing in the Eirich equipment, the preliminary-treated product is discharged to the drier-hardener. It is then differentially screened, and the coarse granules and tailings are returned as may be called for, according to the degree of uniformity of granule required.

Scheme 3 is the type of plant suggested where a batch mixer already exists. Here the constituents for any type of compound fertiliser are introduced to the batch mixer J, from which they are transferred by an elevator to the special treatment vessel F, where steam and bentonite are introduced. After suitable treatment they are passed to the drier-hardener G, from which the product is discharged to the differential screen for separation of the coarse granules and fines, according to the degree of uniformity of granule desired.

Fig. 6 shows a general arrangement of a 5-tons-per-hour Sturtevant granulating plant for superphosphate and compound manures. As is clear, the process of granulation dispenses with the conditioning of the manures, with the subsequent disintegration and redressing. Moreover, after the granules have been suitably cooled, they can be bagged and sent out immediately, and thus, one can effect a saving of storage space and indeed of labour. In point of fact, where granulation is adopted any fertiliser works built in future will need about only half the storage capacity required by the old system, and the labour involved will be appreciably less. Moreover, the plant can be maintained in a clean condition, and an appreciable loss of product in the form of dust avoided. Figs. 7 and 8 show details of the plant.

Present tendencies are for the production of a granule ranging in size from 1.25 to 4.0 mm. The larger the granule, the less the surface area for attack by constituents of the soil, such as lime, clay, or iron oxide, all of which are likely to cause reversion, and equally, the larger the size, the less readily is it dissolved by water. On the other hand, the zone of availability is reduced, as compared with the smaller size. It is clear that many factors may determine the most suitable size of granule for a given soil, namely, the chemical constitution of the soil, its porosity, the nature of the crop, and the rainfall in any particular district. It will be some time yet before all the governing factors have been accurately correlated, but that a marked advance is being made in the manufacture of fertilisers, which will ensure an appreciably greater efficiency of utilisation, cannot be doubted.

According to the Phosphate Co-operative Co., Ltd., of Australia, superphosphate, or

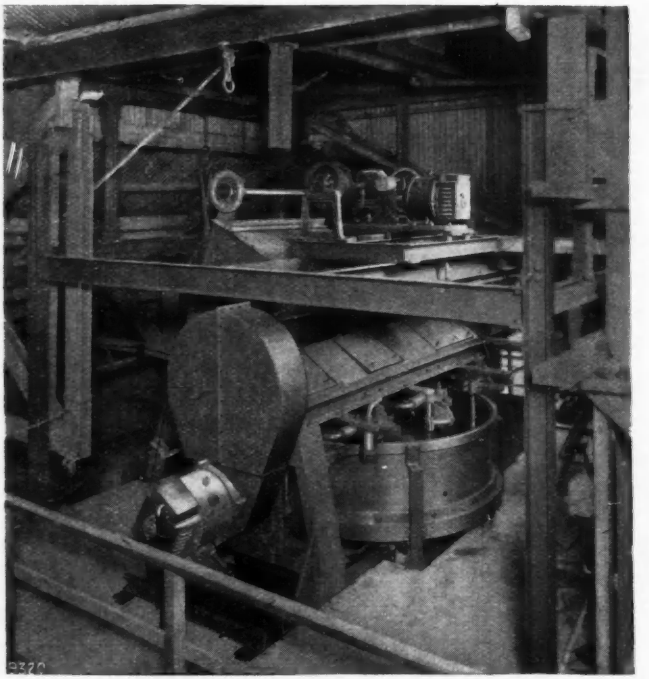

Fig. 8. Eirich type of mixer for granulating manures, and skip-hoist of a Sturtevant granulating plant.

a mixed fertiliser containing superphosphate, should be granulated by feeding it to, and projecting it from, a pair of rollers, suitably spaced and travelling at high peripheral speed. The fertiliser must, however, be of optimum plastic consistency, and this may involve adjustment of the water content either by wetting or by the addition of dry fine material. The best peripheral speed is said to be approximately 4000 ft. per minute, and the distance through which the projected particles are allowed to fall through the gaseous medium for drying and cooling is preferably not less than 60 ft. It is claimed that a particularly uniform degree of granulation is possible by this method.[28]

In America the ammoniation of calcium superphosphate has been pursued for some time, but there are, of course, obvious limits to which anhydrous ammonia or ammonia liquor can be employed. Where anhydrous ammonia is used it is preferable to provide a void tower, in which the superphosphate to be ammoniated is suitably distributed, so that the best possible contact can be arranged. Virtually, what is required is the passage of the superphosphate, of reasonably uniform porosity and grain size, through an atmosphere of anhydrous ammonia. Circulation must be continued until practically the whole of the free phosphoric acid which all superphosphate contains is converted to monoammonium phosphate. To proceed further than the latter stage with the circulation would result in reversion of the superphosphate, which would certainly be undesirable. Where ammonia liquor is employed, this involves application in atomised form to the superphosphate in a suitable chamber. The treated phosphate must then be dried to remove the added moisture, unless one desires to granulate the ammoniated product.[29]

A conference was recently held in the U.S.A. to consider problems relating to the production of ammonium nitrate of improved physical properties. Experimental work at present in progress aims at the prevention of caking and deliquescence, and to this end methods of graining, granulation, and coating have been evolved.

This country is receiving its supplies of muriate of potash for agricultural purposes from America and Russia. The Russian product arrives in a rather damp condition, and occasions trouble on the conveyor belts, etc. The American product, which is in paper bags, is in much better condition.

As a result of investigations by the Agricultural Research Council, which have been

in progress during the last two or three years, the Minister of Agriculture has been able to report on the value of sewage sludge as a fertiliser. Certain types of sludge, if uncontaminated with injurious industrial effluents, have a definite if limited value as a form of organic manure. Their chief value is as a source of nitrogen, most of the potash and phosphate in the raw sewage being inevitably lost. Sludges also have a value on account of their content of organic material, although this is much less than that of farmyard manure. Consideration has been given to the composting of sewage with town refuse, but since such refuse is of very variable material, trials with these composts have not always given promising results. Attention has, however, been directed to the possibility of composting sewage sludge with straw, and investigations along these lines are now being actively pursued. If such a procedure proves successful it will have the great advantage of returning surplus straw to the land, together with its natural content of potash and lignin.[30]

Humus *versus* Fertilisers

It would be wrong to ignore a controversial question[31] which has arisen in an acute form during the year. For soil fertility, humus and compost heaps are a fetish with Sir Albert Howard and his disciples, and indeed with others. But a more powerful case has been presented by Lady Eve Balfour in her book, *The Living Soil*. In this the authoress goes further than Howard in her endeavour to show why this school of thought attacks artificial fertilisers, and demands more humus. She contends that plants do not grow simply by absorbing plant nutrients out of the soil solution *via* the hair-root system. This, she observes, is the theory of the chemist. She maintains that the current and correct view is that the healthy feeding of plants is dependent upon mycorrhizal infection of its roots. This parasitic attack by fungus represents Nature's method of bridging the gap between plants and soil food. Where mycorrhizal development is inhibited the plant suffers from malnutrition, and disease and pest attacks become more and more prevalent. The primary chemical argument of this school of thought is that "artificial fertilisers" inhibit mycorrhizal development, particularly "artificials" containing the sulphate ion. With certain soils bacteria can reduce the sulphate ion to hydrogen sulphide, the presence of which makes mycorrhizal growth impossible. It is further suggested that plant nutrition is in the wrong hands, *viz.*, those of the soil chemist, whereas it would be more appropriate if it were relegated to the domain of the microbiologist and plant pathologist. In fact, the inhibiting effect of the sulphate ion upon mycorrhizal development in the soil has not been proven. Moreover, the case against artificial fertilisers in general cannot be established simply by indicting the sulphate ion. What Lady Eve Balfour proves is that the addition of humus promotes healthy growth, because it is essential for proper development.

Presumably, however, the British Sulphate of Ammonia Federation is not concerned with polemic discussions, but is content to be judged on actual yields of crops. Mr. Hudson, the Minister of Agriculture, has declared that the yields this year of cereals and root crops exceed anything hitherto attained, and more sulphate of ammonia has been used than ever. If the test is "by their fruits ye shall know them," then sulphate of ammonia, and indeed other fertilisers, need no other acclaim. The fact is that humus and fertilisers generally are complementary. Chemists should devote themselves to the economic production of synthetic humus, and this should be applied to soils according to requirements, along with an application of well-balanced fertiliser constituents: nitrogen as ammonia; potash; and soluble phosphates. Their combined influence should be determined, and not less so their individual contributions towards increased fertility.

Small wonder that these controversies have led important fertiliser manufacturers to seek technical advisers who can keep them posted on technical matters concerning the requirements of the agricultural and horticultural industries in respect of fertilisers and other products manufactured, and similarly, keep them *au fait* with the technical progress and development of fertilisers in this and other countries.

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Progress in Drugs and Fine Chemicals in 1943

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THE field of fine chemicals and drugs has been dominated during 1943 by developments in the production and clinical exploration of bacteriostatic substances. War-time urgency has given those materials a status which, almost certainly in the case of one of them, could probably not have been achieved in the pre-war years. These same war-time necessities have brought about a co-operation and a co-ordination of effort, not only between various manufacturers in this country, but between groups of manufacturers in Britain, U.S.A., and Canada, each under the ægis of the respective government authority, which must be unique in the history of industrial chemistry. In particular, the co-operative effort which has been applied to the varied aspects of penicillin production has succeeded in fusing the academic and industrial approaches, which all too often are difficult to adjust.

With regard to the problem of penicillin production the information which has been made available is, from the technical point of view, all too meagre: details about penicillin have been held back for security reasons. The layman has been relatively better served, but because of the lack of understanding of the limitations of lay appreciation, the popularisation of this subject has come to verge almost upon misrepresentation. Such is the lack of perspective which has been induced in the public mind that the drug, which has most specific applications, has become to be regarded as a cure-all. The combination of this circumstance with the making of a number of requests in Parliament for the release of quantities of the drug (which is in short supply) for individual civilian cases led to a statement in September by the Medical Research Council, couched in no uncertain terms, to the effect that the difficulties of large-scale production of penicillin were such that supplies for some time to come would be allocated mainly to military needs. However, the statement added that the balance that might be available for civilian requirements would be used at four unnamed centres for the treatment of systemic infections. At the time the statement was issued it was contemplated that four further unnamed centres would receive limited supplies for topical application. A committee on clinical trials of penicillin would allocate the restricted supplies in such a way that the maximum clinical knowledge would be gained.

It is generally understood that in this country large-scale production of penicillin has been undertaken by the constituent members of the Therapeutic Research Corporation and by I.C.I. (Pharmaceuticals), Ltd., with, perhaps, an additional firm also co-operating. It was announced in April that the unnamed manufacturers are represented on a penicillin production committee under the chairmanship of the Deputy Director of Medical Supplies (Ministry of Supply) on which, significantly, also sit the organic chemists, Professors I. M. Heilbron, H. Raistrick and Sir Robert Robinson.

A committee on clinical trials of penicillin, already mentioned, was set up in March, under the ægis of the Medical Research Council, and it is notable that on this committee sit, among others, Professors A. Fleming and H. W. Florey.

American Work on Penicillin

The efforts of the U.S. manufacturers seem to be similarly co-ordinated; while Canadian manufacture is proceeding in association with the Banting Research Laboratories of Toronto. It is generally understood that there is an interchange of information between the three national groups and that the production capacity of each group is almost entirely directed towards serving military requirements.

Both here and in America contributions to the medical press have become increasingly frequent, to the extent that the literature on the clinical aspects of penicillin is already becoming comprehensive. However, no information has been published in this country on penicillin production since Florey's classic paper in *The Lancet* in 1941. Photographs of fermentation vessels and fermentation rooms appeared in the lay-press in the past autumn which indicated that, if the said photographs truly illustrated current practice (which seems extremely likely from other published information) no advance has been made on the small flask-type of fermenting vessel originally introduced by Florey and his co-

workers. It seems unlikely that the large amount of experience of industrial mould fermentations which has been accumulated in the past 15 years has not been drawn upon in this great co-operative enterprise. Indeed, Messrs. Chas. Pfizer Inc., who are well known as manufacturers of citric acid by a mould-fermentation method, are one of the U.S. group of twelve or so penicillin producers. It is not generally known at the date of these notes to what extent the two major producers of fermentation citric acid in this country have been consulted if, indeed, they have been consulted at all. In all the circumstances it may be reasonably concluded that there are definite biochemical obstacles in the way of translating penicillin production from fermentation in "bottles" to the "trays" or "tanks" characteristic of other industrial mould fermentations.

The Handling of Moulds

One of the main difficulties in handling mould fermentations is the great superficial area which is required relative to depth of culture liquor. The problem is particularly acute in penicillin production, where a superficial area of no less than 500 sq. cm. per litre of culture fluid is required for optimum results. Clifton (*Science*, 1943) of Stanford University has recognised the analogy in this respect between penicillin fermentation and the so-called "quick vinegar process," and has obtained promising results with glass tubes 4 ft. in length and 2 in. in diameter packed with wood shavings. As might be imagined, the main difficulty was to sterilise the apparatus and to maintain sterility, and this is of prime importance, as penicillin is easily attacked and destroyed by bacteria though this may seem paradoxical at first sight. Clifton used the usual modified Czapek-Dox medium, and observed the earlier development of penicillin when corn-steep liquor was used. This latter observation parallels that by Florey who, however, used yeast extract. The effect of providing growth-substances is to increase the rate of mould growth, and thus penicillin appears earlier in the culture fluid, and reaches its maximum concentration earlier; but the gross output of penicillin is not itself increased.

Three interesting contributions to the literature of penicillin have been made in Canada and U.S.A. in the past autumn. Lucas (*Canadian Chemistry and Process Industries*, 1943, *27*, 529) gives the best summary to date of knowledge on penicillin and other bacteriostatic substances of mould origin. The same ground is covered in a list of references to the literature published in Ottawa by the National Research Council of Canada. From the laboratories of Messrs. Chas. Pfizer Inc., of Chicago (*Chem. Eng. News*, 1943, *21*, 1431) comes a less important though interesting contribution, describing some aspects of the techniques used by this firm in producing and testing penicillin. Both Lucas and Pfizer gloss over the technique of large-scale production. Florey, in his original paper in 1941, revealed the labile nature of penicillin and showed that, as a consequence of this lability, the loss of active substance in the working up of the metabolite solution was very great. Florey did, in fact, recover only 30 per cent. of the penicillin in the metabolite liquor, and there is little doubt that energetic steps have been taken since to improve upon this yield. Bearing in mind the distribution co-efficient, no doubt better solvents or liquid/liquid extraction have been found than Florey's amyl acetate; no doubt improvements have been made in the control and conditions of elutriation: and no doubt ways of increasing the speed of contacting and separating the phases have occurred to the chemical engineers concerned, which would improve upon the continuous counterflow column of Florey.

It would seem from the publications of Lucas and of others that it is extremely likely that all processing subsequent to the fermentation operation is conducted at a low temperature and that one of the steps involves freeze-evaporation. It is conceivable that at the date of these notes the actual operations involved in working up the metabolite liquors on a large scale do not differ widely from those used by Abraham, Chain and Florey *et al.* in 1941; but, considering the technical resources available among the firms concerned here and in America, new techniques for carrying out the process operations will surely have been explored.

Data contributed by Lucas, Pfizer and others in 1943 are summarised in the accompanying table and compared with data given by Abraham, Chain and Florey in 1941. The comparison gives an interesting measure of the progress which has been made.

	1941 Florey	1943 Lucas; Pfizer; *et al*
O.U. per ml. of metabolite solution	1–2	about 25–50
O.U. per mg. of "clinical" penicillin salt	40–50	100–400
Recovery of penicillin from metabolite solution	about 30%	probably over 50%

From this table it will be seen that an increased yield of penicillin has been obtained in the fermentation section. Further, a very substantial improvement has been achieved in the recovery of penicillin from the metabolite liquor and, at the same time, the "clinical" penicillin is very much more pure than that obtained by Florey and co-

workers. The "Oxford Unit" (O.U.) is an arbitrary unit, in terms of which the bacteriostatic power of penicillin is measured and refers back to a sample of the purest penicillin available at the time at which the unit was first postulated. "Clinical" penicillin is considered to be about 20 per cent. pure, and is free of fever-producing substances; the balance consists of pharmacologically inert material. Increased purity can only be obtained by special methods, with considerable further losses and therefore at considerable extra cost.

The Cost of Penicillin

The cost of producing penicillin has recently become available from American sources which give a figure of £100 per gram. The point has not been stated, but there can be very little doubt that this figure will have included the very heavy research charges to date. There are good reasons for believing that the *order* of the yield from the fermentation section is not likely to be substantially different from what has lately been obtained so that yield from this section of the process is bound to be a limiting factor in cost reduction. Nevertheless, bearing in mind the achievements of large-scale mould fermentations for other products, it is reasonable to hope that the cost given above could be ultimately cut to a quarter of the figure, ignoring the charging of research overheads.

It was stated in September that the Canadian Government was providing funds for the establishments of two plants and the manufacture of the first 26,000 million units of penicillin which would employ 250 people. This quantity represents, approximately, the annual production capacity of the plants, and the output is to be taken up by the Canadian armed forces. One gram of clinical penicillin may be taken roughly as 200,000 Oxford Units so that the annual Canadian output is of the order of 130 kg., costing, on the basis of the American figures given above, £13 million or less according to the reduction in cost which will be made by large-scale working.

It may be expected that large-scale production is being undertaken in this country and in U.S. roughly on a *pro rata* basis with the population, and it is likely that such deduced figures are even exceeded. It is not known to what extent Government funds have been made available in this country. In co-ordinating effort it is clear that, as a minimum contribution, the Government is giving such facilities as are required to make plant, labour and raw materials available. Neither is it generally known to what extent new entrants in the field of manufacture would be given these facilities.

From these figures it is clear that the investigation of the possibility of synthesis will be actively pursued. Before synthesis can be attempted the constitution of penicillin must be established, and that this aspect is not being neglected is implicit in the membership of the penicillin production committee mentioned above.

The provision of the pure substance for characterisation of structure is a problem in itself. Lucas in the survey mentioned above describes one method by which "clinical" penicillin is first reduced with aluminium turnings at pH 7.0, and subsequently solvent-extracted as barium penicillin. A substantial purification is achieved but only with heavy sacrifice of yield. Another method due to Catch, Cook and Heilbron (letter to *Nature*, 1943, *150*, 633) elaborates the method of adsorption on alumina which was used originally by Florey *et al.* Heilbron and co-workers have developed an adsorption base consisting of silica gel on which strontium carbonate has been precipitated. This column-packing absorbs the penicillin components from ether or ethyl acetate solution in zones according to the relative strengths of the component acid substances. After elutriation the strontium salt of penicillin gave 500-700 O.U. per mg., which was the highest bacteriostatic power obtained up to the time of publication of their letter. Preparations with this bacteriostatic activity would be able to inhibit the growth of *Staphylococcus aureus* at about a dilution of 1 in 30 million, while leucocytes are still able to survive exposure to 1 per cent. solutions; but it was considered that the material was still far from being pure. After drying, the sample gave an analysis corresponding with $C_{21}H_{34}O_{11}N$ Sr. There is no evidence that these methods have been used beyond the provision of small quantities of highly-purified penicillin for special purposes. Chromatographic adsorption technique has not yet developed to the point of being a unit operation in chemical engineering, so that the method is still probably restricted to experimental work.

Known Characteristics

The most recent summary of the known characteristics of penicillin was given by Abraham, Chain and Holiday in 1942 (*Brit. J. Exp. Path.*, 1942, *23*, 103) and their findings concerning the barium salt of penicillin, the sample of which was homogeneous by chromatographic analysis, were as follows: strong dibasic acid, $pk_1 = 2.3$ and $pk_2 = 3.5$; formula, $C_{24}H_{32}O_{10}N_2Ba$, but C_{23} and C_{25} formulæ not excluded; one carbonyl group; one latent carboxyl group; two acetylatable groups; at least five C-CH_3 groups; an unsubstituted α-β-unsaturated ketone group may possibly be present. There is no easily reducible double bond; no O-CH_3 group; no N-CH_3 group; the acidic groups are not conjugated with the chromo-

phore responsible for adsorption. Penicillin is unstable in the presence of oxidising agents and, to a less extent, in the presence of reducing agents; it is unstable to acids, alkalis, heat, primary alcohols and heavy metals.

Abraham, Chain and Robinson have isolated the first stable crystalline derivative of penicillin by mild acid hydrolysis (letter to *Nature*, 1943, *151*, 107). This derivative, penicillamine, appears to have the formula $C_9H_{11}O_4N.HCl$ after losing one molecule of water on drying. It seems to possess some of the properties of an amino sugar and of ascorbic acid with enolisation.

Duffin and Smith made an ether extract of a penicillin solution which had been maintained at *p*H 2.0 until the optical rotation was constant. Eventually, penicillic acid was isolated and crystallised from butyl alcohol, and this had the remarkable optical rotation in aqueous solution (C=0.2) of +600°C.

Mayer, Hobby and Chaffee (*Science*, 1943) attribute the lability of penicillin in some measure to its carboxyl groups, which they esterified. These esters were all active when administered to infected mice, with the exception of the benzohydryl derivative which seemed to resist hydrolysis to its constituents. It seems that some measure of economy of penicillin might be obtained through the use of these esters, as they are better retained by the body than penicillin, which is very rapidly excreted.

Possibility of Synthesis

It appears that synthesis of pencillin is not likely to be achieved for some time. Indeed, a situation may be found to arise, similar to the position of certain complex alkaloids, where a structural formula *may* ultimately be advanced which fits all the facts but lacks a final proof because actual synthesis is found to be unattainable. The classic work of Robinson *et al.* on morphine comes to mind in this respect. Should such a situation develop in the case of penicillin, it is to be presumed that subsequent work would follow the lines of finding chemical and pharmarcological analogues simpler in structure and capable of synthesis. Such an exploration would in fact be desirable from other points of view, and particularly from the consideration that penicillin is far too rapidly excreted in the urine to be an ideal bacteriostat. What would be desired would be a bacteriostat with at least the same activity, specificity and lack of toxicity, together with an improved stability and capable of greater retention within the body.

The ease with which penicillin is excreted makes it necessary to give massive doses in order to maintain the level of concentration in the blood, and well over half-a-million Oxford Units may have to be administered in a single case subject to severe infection. This is not a serious obstacle from a pharmacological point of view as one of the chief characteristics of penicillin is its remarkable freedom from toxic effects over the range of doses so far administered. The present disadvantages of such massive dosing are, firstly, the need for special means of administration in order to maintain the blood level; secondly, the relative scarcity of the drug; thirdly, its cost. The first disadvantage has been met by the use of the continuous intravenous drip method. The second and third disadvantages are less capable of being met; but, wherever possible, the urine of the patients is collected and some 50-60 per cent. of the penicillin administered may be recovered.

Clinical Trials

In the meantime, there is no lack of information regarding the clinical trials which are taking place and an extensive literature is commencing to accumulate on this aspect of the subject. As these trials proceed the limitations of penicillin therapy become more clear-cut; but at the same time in its own by no means narrow field of application penicillin shows every sign of fulfilling the brightest hopes and within its own limitations justifies its description in the popular press as a " wonder drug." It continues to be confirmed that penicillin is predominantly useful against gram-positive cocci, a field in which alternative bacteriostats are often less powerful; penicillin, moreover, has other advantages in specificity and intensity of action. Recent successful indications for penicillin therapy have been the treatment of surface and sub-surface wounds among troops in N. Africa; in ophthalmology and in the treatment of burns. A valuable application is in gonorrhoea where the coccus is especially liable to develop sulphonamide resistance.

Evidence of synergism between penicillin and *p*-aminobenzoic acid has come to hand. Moreover, when it is remembered that *p*-aminobenzoic acid is antagonistic towards the sulphonamides, it is a remarkable fact that it has now been found that sulphapyridine is more active synergistically towards penicillin than is p-aminobenzoic acid (Ungar, *Nature*; 1943, *152*, 245).

The assay of penicillin presents a peculiar problem. Nevertheless, two further methods have been suggested during the past year in addition to the established " cup " method of the Oxford workers and the serial dilution method of Florey. One method emanating from the Wellcome Research Laboratories depends upon the colorimetric estimation of the degree of haemolysis of a suspension of sheep blood-cells by a B-haemolytic streptococcus under standard conditions with varying quantities of inhibiting penicillin. The second method depends upon the degree of inhibition of the enzyme

urease by penicillin, and in this case the method seems to be not yet fully standardised. No reference has yet occurred in the literature to the perplexing problem of testing penicillin preparations for sterility. The remarkable character of penicillin has tended to obscure the fact that it is far from being the only antibiotic material obtainable from the lower organisms of the vegetable kingdom. Other substances referred to in the literature from time to time include gramicidin and tyricidin from *Bacillus brevis*; actinomycin from *Actinomyces antibioticus*; citrinin from *Penicillium citrinum*; penicillic acid from *Penicillium puberulum*; and Patulin from *Penicillium patulum*. Helvolic acid is interesting as being secreted by another species of mould, *Aspergillus fumigatus* mut. helvola. *Penicillium notatum* may secrete penicillin, penicillin mixed with other bacteriostats, or no penicillin but solely other bacteriostats, according to strain and conditions. Among these latter substances are notatin and penicillin B, which are possibly identical, and penatin.

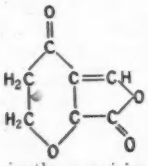
Bergel *et al.* (*Nature*, 1943, *152*, p. 750) claim to have established the chemical identity between claviformin (metabolite of *Penicillium claviforme*) and clavatin (*Aspergillus clavatus*), and offer good grounds for their belief that claviformin ($C_7H_6O_4$) is also identical with patulin. These authors are unable to agree with Raistrick's structural formula for patulin; further information on this point has not been published at the date of these notes, but is expected to appear elsewhere very shortly.

Notation : Gramicidin

Notatin inhibits *Staphylococcus aureus* in the remarkable dilution of 1 in 1000 million; but it is only active in the presence of glucose and oxygen and in the absence of catalase. It appears to be a flavoprotein and an enzyme of the glucose aerodehydrogenase type. Notatin occurs in the culture liquor at a concentration of 3-4 grams per 100 litres and a method of preparation is protected in this country under letters patent (B.P. 552,619). Gramicidin appears to be limited in use although it is highly bactericidal towards gram-positive organisms; this is because of a toxic action arising from its powerful haemolytic action on red blood corpuscles. It has been shown to be a polypeptide and the 24 constituent amino-acids have been identified (Gordon *et al.*, *Biochem. J.*, 1943, *37*, 86).

Helvolic acid is predominently bacteriostatic, although its potency is probably too low for clinical use. It acts almost exclusively against gram-positive organisms and is not inhibited by *p*-aminobenzoic acid. Administration in sub-optimal concentrations develops resistance in the infecting organism which, however, is still susceptible to penicillin. It appears to have the formula $C_{32}H_{44}O_8$.

Patulin, like penicillin, has been considerably publicised in the lay press. A metabolic product of *P. patulum*, Bainier, it has been prepared by Raistrick and his coworkers from Raulin-Thom medium in the substantial yield of 1 gram of crystalline product per litre and has been made available for clinical trial by one of the penicillin manufacturers under the brand name "Tercinin." It is a considerable bacteriostat though not so active against gram-positive organisms; on the other hand, it has the advantage of being almost equally as active against gram-negative as gram-positive organisms, and showed no selective action between them. Serum and pus do not interfere; but there is an upper limit of dosage due to toxic action and to interference with phagocytosis. Raistrick suggests its structure is anhydro-3-hydroxy-methylene-tetra-hydro-γ-pyrone-2-carboxylic acid.



Patulin has been tested against the common cold and is claimed to be effective in abbreviating the conditions due to the secondary infection. There is, however, conflicting evidence; but results have been sufficiently promising for the Medical Research Council to undertake more extended trials. There is, moreover, some doubt as to whether the action of patulin in the treatment of the common cold is entirely bacteriostatic, as the possibility of pharmacological action is not ruled out.

Sulphonamides

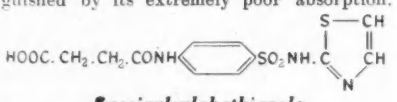
Parallel with the work on the bacteriostatic substances of natural origin has proceeded the continued development of the sulphonamide group. Clinical experience continues to accumulate concerning the six main drugs of this group—sulphanilamide, sulphacetamide, sulphadiazine, sulphaguanidine, sulphapyridine and sulphathiazole—and increasing importance is attached to knowledge of the amount of drug, both free and acetylated, circulating in the blood stream and excreted in the urine. This knowledge is especially essential in cases of severe infection when it is desirable to reach rapidly, and then to maintain, an optimum concentration of the drug in the blood. Factors which may operate against this being reached by empirically calculated doses thus leading to inadequate blood levels are: variability of adsorption in different individuals; the rendering therapeutically inert of uncertain amounts of the drug by acetylation, which is the route by which detoxication proceeds; vomiting by the patient;

hesitancy on the part of the physician in prescribing heavy dosages for fear of the possibility of early toxic reactions appearing, due to personal idiosyncrasy. Moreover, it is desirable to know at an early stage in the treatment whether lack of response is due to inadequate blood concentration of the free drug, or to the infection being due to a strain which, on account of injudicious treatment with sub-optimal doses in the past, has acquired sulphonamide-resistance. In the latter case resort to an alternative bacteriostat would be urgent.

In War Memorandum No. 10, the Medical Research Council have published a useful summary of "The Medical Use of Sulphonamides" (1943), and Appendix 1 details convenient laboratory procedures for estimating the concentration of sulphonamides in body fluids by colorimetric methods. In Bratten and Marshals' method the sulphonamide is diazotised and coupled with N-(1-naphthyl)-ethylene-diamine which gives a red colour; in a less advantageous method the yellow colour obtained by condensing the free-N^4-amino group with *p*-diamethylamino-benzaldehyde to form a Schiff's base is measured. Fuller has adapted the last method as a spot-test on filter paper for approximate assay where rapid results are wanted in clinical use.

There has been considerable development during the past twelve months in the use of sulphonamide powders with or without diluent, and sometimes with inert "anti-caking" agents for the dusting of wounds. A case of clinical tetanus, possibly caused by an infected container of a sulpha-drug prepared for insufflation, has brought to the fore the problem of sterilising such powders. Suitable methods are described in the second appendix to the above-mentioned memorandum, while an official method for "Sulphanilamidum" is described in the newly issued (1943) 6th Addendum to the 1932 Pharmacopœia.

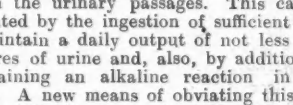
There have been one or two interesting introductions in this country during the past year chiefly of sulpha-drugs developed in America and now manufactured here. Succinyl-sulphathiazole (2-(*p*-succinyl-aminobenzene sulphonamido)-thiazole) is distinguished by its extremely poor absorption.



Succinylsulphathiazole

The blood concentration, therefore, remains extremely low and the main effect of the drug is in diminishing the number of coliform organisms in the bowel. Its use is indicated in surgery of the intestinal tract and for the control of bacillary dysentery, in which field sulphaguanidine was previously the main chemotherapeutic agent. The application of sulphonamides to wounds is always attended by some risk, because of lack of control of absorption and the consequent chances in favour of toxic concentrations being reached in the blood stream. Because of its low rate of absorption, succinylsulphathiazole is largely free from this risk, and from this point of view the drug has been explored in the Middle East with satisfactory results.

One of the more difficult aspects of sulphonamide chemotherapy is the tendency for the N^4-acetyl derivative to crystallise out in the urinary passages. This can be mitigated by the ingestion of sufficient fluid to maintain a daily output of not less than 1½ litres of urine and, also, by additionally maintaining an alkaline reaction in the urine. A new means of obviating this particular difficulty lies in the two newly introduced sulphonamides—sulpha dimethylpyrimidine (2-(*p*-aminobenzenesulphonamido)-4 : 6-dimethylpyrimidine) and its corresponding monomethyl derivative. The



Sulphadimethylpyrimidine

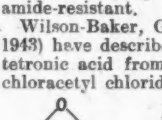
characteristic of these drugs is that they are rapidly absorbed but not readily excreted and the blood concentration is, therefore, maintained with moderate dosage. Further, the drugs and their N^4-acetyl derivatives are more soluble than sulphadiazine and acetylsulphadiazine, respectively, especially if the urine is kept alkaline. With the precautions usually taken with sulpha-drugs, and especially as regards fluid intake, crystal deposition in the kidney tubules and urinary passages may be avoided.

Sulphonamido-urea has recently been introduced in this country and is claimed to be especially effective in infections by organisms which have acquired sulphonamide-resistance. It is claimed that this drug antagonises sulphonamide inhibitors, that bacteriostasis is increased and toxic effects reduced.

The acquisition of sulphonamide-resistance by infecting organisms is to be avoided at all costs, and it is possible that what may yet prove to be irreparable damage to this branch of therapy may have been done before this point was sufficiently realised. It is important that this should not be allowed to happen in the case of penicillin and other new bacteriostatic agents. The phenomenon of "training" micro-organisms to tolerate what would otherwise be toxic concentrations of a given substance is well known in industrial microbiology. The toleration is usually achieved by passing

successive sub-cultures through medium containing increasing concentrations of the toxic material, and it appears that something of this nature occurs in the body fluids and tissues where sub-optimal doses of sulpha-drugs are administered. Hence the necessity arises from this, as well as other causes, to obtain the optimal concentration of the sulphonamide in the blood stream by massive doses, short of toxic reactions, at the start of the treatment. Where sulphonamide-resistance has developed, recourse must be had to other bacteriostats such as penicillin and, indeed, resistance to one is an indication for the use of the other. Notable successes have been obtained thus as has been mentioned in gonorrhoea, which has a marked capacity for becoming sulphonamide-resistant.

Wilson-Baker, Grice and Jansen (*J.C.S.*, 1943) have described the synthesis of α-acyltetronic acid from anilinocrotonic acid and chloracetyl chloride. The importance of this acid is its relationship to certain mould metabolic products. The methyl group is very reactive and can be condensed with amino groups to form unsaturated compounds which, in their turn, can be reduced to α-acyltetronic acids.



In the last war, C. H. Browning and his collaborators introduced acridine derivatives for antiseptic wound dressing The particular preparation used was acriflavine, which was available commercially as a mixture of 2 : 8-diminoacridinium methyl chloride and 2 : 8-diaminoacridine hydrochloride. Among other disadvantages this preparation was irritant to the tissues and, after the war, it passed out of favour. During the past decade a systematic chemotherapeutic survey of the aminoacridines has been undertaken by W. H. Linnell and his collaborators which, with the advent of a second world war, has led to a new exploration of the clinical advantages of this class of compound. As a result, members of the class have recently become available under brand names. Attention has been particularly directed to the potentialities of diflavine (2 : 7-diaminoacridine monohydrochloride), proflavine (2 : 8-diaminoacridine sulphate) and, to a less extent, to 5 : aminoacridine. Although the original acriflavine preparation has a high irritant effect on wounds, Russel and Falconer found that 2 : 8-diaminoacridine, one of the constituents of the original commercial preparation, had little or no toxic action provided that it was applied in solution sufficiently concentrated to be powerfully bactericidal. A natural extension of this observation, coupled with knowledge gained in topical application of sulphonamide powder, has been to apply the solid powdered preparations and this has been done with wounds contracted in the Middle East. 2 : 7-diaminoacridine, being a weaker bactericide, has been found less satisfactory for this purpose than the 2 : 8-compound, although the latter is somewhat more toxic. Furthermore, the 2 : 7-compound stains the skin. The aminoacridines are effective against streptococci, staphylococci and some clostridia *in vivo*; but 5-aminoacridine, which is limited in use because of its toxicity towards leucocytes, is of especial value against *B. proteus* infections. Diflavine, also, has a marked specificity against the pus organism, *Ps. pyocyanea*. Nevertheless, the main disadvantages of the aminoacridines is that they all produce some degree of necrosis of the cells of the walls of the wound. This effect has been studied extensively during recent months from the standpoint that the salts buffer at a low *p*H and this acidity is thought to be the cause of necrosis. Albert and Gledhill, as well as other workers, have given considerable attention to the preparation of salts of aminoacridines other than these official in the Pharmacopœia, the objective being to find salts which, in 0.1 per cent. solution, have a *p*H of about 6.0, which is the approximate *p*H of body fluids. One British manufacturer has been offering a buffered isotonic solution of proflavine since the early days of the present war, and claims that it is the only safe antiseptic for application in surgery of the brain. For this particular use proflavine has advantages to which Browning drew attention and which have been appreciated for some time. However, there appear to be grounds for the belief that the acidity of the salts of the aminoacridines is not an entirely satisfactory explanation of cell necrosis and that irritation of the wounded tissues is, in part at least, an intrinsic characteristic of the acridine nucleus.

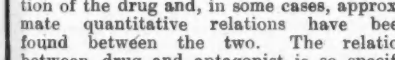
McIntosh and Selbie have recommended a powder mixture of one part proflavine with 100 to 200 parts sulphathiazole as a phophylactic in the first-aid treatment of war wounds.

Ureas

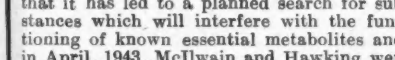
Among the symmetrical ureas and related compounds the three active trypanocides developed by Ewins—stilbamidine (4 : 4^1-diamidinostilbene), propamidine (4 : 4^1-diamidino phenyoxypropane) and pentamidine (4 : 4^1-diamidinophenoxypentane)—are now found to have bacteriostatic properties, and propamidine has been recommended as a first-aid preparation in the treatment of burns. These three diamidines, which have been in use for sometime to control kala-azar in India and the Sudan, have been found to have a bacteriostatic power against *Staphylococcus aureus* in vitro of the same order as that of sulphathiazole. One of the difficulties of administration of stilbamidine

in cases of kala-azar is that the preparation develops an increasing toxicity on exposure to light. Barber, Slack and Wien (*Nature*, 1943, *151*, 108) believe this toxicity to be almost certainly due to 4 : 4¹-diamidino phenyl benzyl carbinol which they believe to be formed from the di-β-hydroxyethane-sulphonate salt of stilbamidine under the influence of light resulting in a change associated with the unsaturated stilbene linkages.

Since Ehrlich's time there has proceeded an unceasing search for the fundamental mechanisms by which drugs act. Chemotherapy, the particular branch of study in which chemicals that are benign to the host and yet inhibit the development of the invading parasite, are introduced into the host's body-fluids, has already yielded rich results. Particularly is this the case with the approach from the standpoint of the study of drug antagonists. The discovery by Woods that *p*-aminobenzoic acid was the principal antagonist responsible for anti-sulphonamide activity both *in vitro* and *in vivo* has been farther developed from the knowledge that enzymes can generally be inhibited by substances which are structurally related to their respective substrates. It is believed that sulphanilamide is able to pre-occupy the enzyme system which is concerned with the metabolism of *p*-aminobenzoic acid, a substance essential to the growth of certain pathogenic micro-organisms. Sulphanilamide and *p*-aminobenzoic acid are clearly structurally related. The concentration of the antagonist in the tissues of the host is as important as the concentration of the drug and, in some cases, approximate quantitative relations have been found between the two. The relation between drug and antagonist is so specific that it has led to a planned search for substances which will interfere with the functioning of known essential metabolites and, in April, 1943, McIlwain and Hawking were able to announce a successful outcome of the first planned investigation along these lines. Knowing that the vitamin-like substance, pantothenic acid, was essential to certain classes of micro-organisms, which obtain it from the tissues of their hosts, these workers and their collaborators obtained a series of structurally related substances and among



Pantothenic acid.



Pantoyltaurine.

them found that pantoyltaurine antagonised pantothenic acid *in vitro*. Rats were then inoculated with very heavy dosages of a particularly virulent strain of *Streptococcus haemolyticus* and it was found that, so long as the ratio of pantoyltaurine to pantothenic acid in the blood was maintained at a suitable level, these animals were completely protected from 10,000 times the lethal inoculation of the particular invading organism. This remarkable achievement indicates one of the lines which will now be increasingly followed in exploring for new chemotherapeutic materials.

Medawar, Robinson and Robinson (*Nature*, 1943, *151*, 195) have examined the steam distillate from malt extract which, with other substances of natural origin, is known to contain a substance which, while inhibiting the growth of fibroblasts and other mesenchyme cells, permits the free growth of epithelial tissues. They identified almost certainly the active substance with δ-$\Delta^{\alpha\beta}$-hexenolactone. This substance was obtained in small yield by condensing acetaldol with malonic acid in pyridine, and was found to exercise the same differential growth inhibition as the substance isolated from the malt extract. The authors believe that the action of δ-hexenolactone is to inhibit a growth factor more specifically required by fibroblasts than by epithelial cells and this growth factor is provisionally thought to be pantothenic acid. If this should prove to be the case the use of δ-hexenolactone is indicated as a bacteriostat against haemolytic streptococci for which pantothenic acid is an essential metabolite.

The "Receptor"

Implicit in the consideration of the mode of action of sulphonamides is the conception of a receptor within the cell of the micro-organism for which the drug and its antagonist compete. The nature of combination with the receptor is unknown; but it has been indicated that it is believed to be of the same nature as that of an enzyme-substrate complex. Drug and antagonist, in the case of sulphanilamide and p-aminobenzoic acid, have like chemical structure; and like pharmacological action may, moreover, be attained in general from substances of like chemical structure; but substances which are not similar in chemical structure may yet have similar pharmacological action. The antimalarials quinine, pamaquine and mepacrine may be cited as examples of the latter. These antimalarials are believed to act through interference with the respiratory mechanism of the malarial organism, the rate of oxygen consumption for which is high and critical. It is believed that the similar effect of these antimalarials is exerted through a similar basicity rather than through structural resemblance, the existence of two pk constants within a certain range being a limiting feature. Christopher

is of the opinion that through this common basic make-up these drugs interfere with a hydrogenase-cytochrome-oxidase system in the infecting plasmodium. Christopher's paper on this subject was one of a dozen read at an important general discussion on "Modes of Drug Action" organised by the Faraday Society in September, the records of which will well repay study.

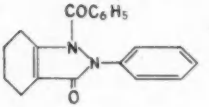
An interesting contribution towards knowledge of the mode of action of antiseptics has been made by Evans and Fishburn. They suggest that water-soluble bactericides are first adsorbed on the plasma membrane surface of the micro-organism, and this adsorption is then followed by chemical reaction between the adsorbed bactericide and membrane protein. Coagulation of the latter ensues up to the point at which the life-process is unable to continue. In support of the theory of initial adsorption they found that, when activated carbon (representing the organism) was shaken with phenolic disinfectants, which were in concentrations less than 1 per cent., the weights of bactericide adsorbed per gram of carbon were approximately of the same order as the bactericidal powers measured by the Rideal-Walker coefficient.

Antimalarials

Following the original restrictions placed on the handling of cinchona alkaloids in August, 1942, still more drastic restrictions were introduced in January, 1943, in the shape of S. R. & O. 1943, No. 2668, imposing control over the prescribing, dispensing and supplying of antimalarial preparations, whether of natural or synthetic origin. Since the loss of our eastern possessions to the Japanese the manufacture of the synthetic antimalarial substances mepacrine and pamaquine has been actively prosecuted in this country. Price reductions made during the past year reflect, no doubt, that difficulties in adapting some of the steps to large-scale operation have been, in part at least, overcome. The synthesis of these druugs, which are of the utmost importance to the cause of the United Nations in their military undertakings in the Far East and elsewhere, is also being actively pursued in America. Just as the publication of technical matter regarding penicillin has been more free in Canada and U.S., so with the antimalarials. An interesting description, with illustrative material, of manufacture of these antimalarials in the U.S. has been given by A. E. Sherndal (*Chem. Eng. News*, July, 1943). A. W. Mortimer in a survey of the work of the Directorate of Medical Supplies, Ministry of Supply, given to the Pharmaceutical Society in December, stated that there was no shortage of these synthetic antimalarials to the Services and that the joint output of Britain and the U.S. was, dose for dose, more than double the peak annual output of quinine in Java.

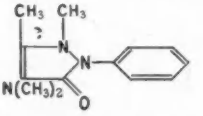
Analgesics

The search for new analgesics continues. Picard, Seymour and Dyer have devised a simplified method for preparing tetrahydroindazolones (or *cyclo*-tetramethylene pyrazolones), which substances have been claimed by other workers to have strong antipyretic activities. Their method is to allow a salt of phenylhydrazine to condense in alkaline solution with ethyl *cyclo*-hexanone-2-carboxylate to yield tetrahydroindazalone. This substance could then be alkylated or acylated in boiling alcoholic potash



1-phenyl-2-benzoyl-tetrahydroindazolone

solution. As an example, they found that 1-phenyl-2-benzoyl-tetrahydroindazolone is non-convulsive, only slightly soporific, and



Amidopyrine

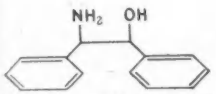
much less toxic to rats or mice than the corresponding 2-methyl compound or the well-known amidopyrine.

Their findings regarding the analgesic activities of these indazolones have yet to be published at the date of these notes.

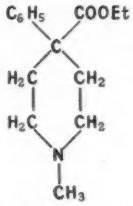
The analgesic par excellence remains morphia; but in view of its well-known limitations it is not surprising that attempts continue to be made to discover substitutes which are comparable with it in analgesic activity, and yet without its acknowledged less desirable characteristics. Small and his co-workers have been working upon this problem in America for some years, their approach being to determine the pharmacodynamic nucleus and groupings of morphia and then to so modify them that the undesirable morphine properties are eliminated.

This approach has only attained a very limited measure of clinical success to date. Dodd and co-workers, in this country, have worked from another angle which is the development of a relatively easily synthesised compound bearing the same relationship to morphine as the synthetic oestrogens do to the naturally occurring sex-hormones. The analogy is supportable in theory by the additional fact that the phenanthrene nucleus is common both to morphine and the naturally occurring sex-hormones. Dodd and co-workers (*Nature*, 1943) state that some progress has been made in the diphenyl ethylamine series, the most active com-

pound yet found being β-hydroxy-α β-diphenylethylamine when administered per os in 50 to 400 mg. quantities at four hourly intervals.



β-*hydroxy-* α β-*diphenyl-ethylamine*

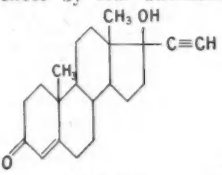


Pethidine

Another substance which has been proposed as a substitute for morphine is "pethidine" (also known abroad as "demerol" or "dolantin") which is the ethyl ester of 1-methyl-4-phenylpiperidine-4-carboxylic acid, discovered in 1939 by Eisleb and Schaumann in a search for a synthetic substitute for atropine. Among its other properties pethidine is to a certain extent a spasmolytic and in this respect bears a resemblance to atropine. The analgesic effect of pethidine is mainly directed against pain involving the smooth muscle, and it appears to be much less effective against pain of skeletal or neural origin. It has slight advantage over morphine in the alleviation of post-operative pain, in that it does not cause constipation as does morphine. However, in an important respect pethidine fails signally, in that both toleration and addiction may develop, and, although these characteristics may not be so pronounced, no analgesic is likely to substitute morphine, except in very exceptional circumstances, unless it is almost entirely, if not completely, devoid of the characteristics named. Thus, with increasing experience of the use of pethidine the initial high optimism has not proved justified and, as one writer has said, there is now a "modified enthusiasm."

Adams in America, and Todd in Britain, together with their co-workers, continue their study of the resins of Indian hemp, *Cannabis indica*. The resin is predominantly hypnotic but with substantial analgesic properties. It contains, among other constituents, cannabinol and cannabidiol, which are not active themselves but which may, by catalytic reduction, be converted to highly active principles. The active principle of Indian hemp has not yet been characterised; but it is now thought to be a member of the same series as the synthetic tetrahydrocannabinols.

"Ethisterone" is the synonym now approved by the General Medical Council for the ketosterol, ethinyltestosterone, the analogue of the corpus luteum hormone, progesterone, and which produces progestational effects in the human female on oral administration. Methyl testosterone, the synthetic male hormone which produces the same effect by oral administration as does the



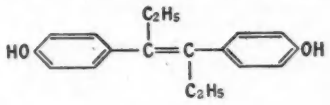
Ethisterone ***Testosterone***

naturally occurring androgen, testosterone propionate, by injection, is now available in a suitable form for dissolving beneath the tongue, at which site the highly elaborate capillary network facilitates rapid absorption.

A new androgenic preparation has been made available in recent months which contains chorionic gonadotrophin from human pregnancy urine and the follicle-stimulating principle of the anterior lobe of the pituitary gland. The pharmacological effects of each of these components are similar; but, in combination, a synergistic effect is found in laboratory animals by which a powerful gonad-stimulating effect was obtained.

Stilboestrol (trans-4 : 4¹-dihydroxy-α -β-diethylstilbene), the synthetic oestrogen, has the distinction of being the first sex hormone to be included in the Pharmacopœia (6th Addendum, 1943) itself as apart from the Codex. In December, Dodds was able to announce very promising and hopeful results in the control of cancer of the prostate gland both here and in America by the use of stilboestrol.

Faulkner has explored the bactericidal action of the oestrogens and has found stilboestrol to be bactericidal to gram-positive cocci, *C. diphtheria* and *N. catarrhalis*, while it is bacteriostatic in lesser concentrations. The lethal concentrations lie be-



Stilboestrol

tween 1 in 5000 and 1 in 500,000 and the bactericidal activity is reduced by the presence of serum. Hexoestrol was also found to be bactericidal; but oestrone, oestradiol and diethoxytriphenylbromoethylene were not. Tubercle bacilli were killed *in vitro* by stilboestrol at a dilution of 1 in 500. In connection with this latter micro-organism no bacteriostat has been available until the last month or two when a new preparation, *p-p*¹-diaminodiphenyl-sulphone-N : N¹-didextrose sulphonate has been introduced into

this country from America under a proprietary name. It is claimed that this substance inhibits the development of the tubercle bacillus.

Vitamins

The vitamin K analogues, menaphthonum (2-methyl-1 : 4-naphthaquinone) and acetomenaphthonum are now official in the Pharmacopœia, as also are riboflavin (6 : 7-dimethyl-9-(*d*-*l*'-ribityl)-*iso*-alloxazine) and nicotinamide (pyridine-3-carboxylic acid amide). These substances were introduced into the 6th Addendum to the 1932 Pharmacopœia during the past year.

The Steenbock patents relating to the manufacture of vitamin D with the use of ultra-violet light have been ruled to be invalid by a U.S. court. The origin of the ultra-violet radiation was held to be immaterial, and ultra-violet radiation to be a "process of nature." Stocks of chocolate containing vitamins A, B_1, C and D are being accumulated under Government auspices for the relief of the civil populations of countries as they become freed from enemy occupation. Chocolate is considered to be the best medium for administration of these accessory factors, as the cocoa butter acts protectively against loss of potency.

The past year has seen the maturation of a considerable amount of work undertaken, both in this country and in the U.S.A., in connection with large-scale production of yeast, which is distinguished by its high protein and vitamin B contents. The yeast used is a "wild" variety, *Torulopsis utilis var. grandis*, which is related to that used in Germany for the production of fodder in the last war; diploidy has now been induced in the strain by treatment with camphor to give "giant" cells which facilitates industrial manipulations. The main objective here is the production of a protein and B-vitamin rich food for the liberated countries; but British interests are also directed to a suitable utilisation of the excessive production of sugar-containing materials in the West Indies brought about by reduced exports due to war-time exigencies.

Among the vitamins and similar substances which have been shipped from U.S.A. to Allied destinations during the first 18 months of Lease-Lend are to be noted the following: cafotene in oil solution, 5274 kilos; riboflavin, 1000 grams; ascorbic acid, 16,976 lb.; thiamin hydrochloride, 3965 kilos. Among the intermediates required for synthesis were: cyanacetamide, 4000 kg.; diacetone gulosonic acid, 6475 kg.; and sorbose, 70,320 lb. This list is an indication of important relative deficiencies in British manufacture over the period named.

Following the noting of references in the old medical literature to the breaking open of old wounds and old fractures in persons suffering from scurvy, the use of vitamin C as an agent for promoting the healing of wounds has been investigated. Bourne (*Lancet*, December, 1942) has summarised the function of vitamin C in tissue repair, and it is considered that calcium ascorbate may become of importance in this connection.

Another approach to the problem of promoting the healing of wounds is that of Loofburow who has shown that cells, when damaged by ultra-violet light, secrete growth-promoting factors, the potency of which may be measured by the proliferation of yeast cells in Reader's Solution. The factors resemble "bios," are thermostable and give an absorption spectrum in the region characteristic of purines and pyrimidines. Exploration of the process with radioactive phosphorus suggests that these diffusible substances occur normally within the cell, but are released by a change in permeability of the plasma membrane induced by the radiation. The active substances could not be identified, but a *mixture* of certain known constituents of living cells was found to promote a similar proliferation of yeast cells. Purines and pyrimidines had no effect by themselves; but adenine triphosphate with a vitamin supplement equalled in potency the preparation obtained by damaging the cells with ultra-violet light. What appears to be synergistic effect is to be noted.

English letters patent have been granted to the Institution Divi Thomae Foundation of Cincinnati relating to the preparation of substances from yeast which promote proliferation of animal and vegetable cells. Yeast cells are slowly killed by ultra-violet light during the period of one hour, and death is judged by the usual methylene blue test.

Experimental diabetes can now be induced in rats. Shaw-Dunn has found that injection of alloxan causes lesions and eventual necrosis of the Islets and Langerhans in the pancreas. The physiological significance of the process is not clear; but the relationship between alloxan, uric acid and riboflavin is to be noted.

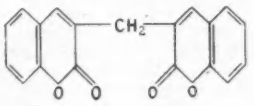
Astwood has investigated the antithyroid activity of a large number of chemical compounds. He found them to fall into two groups—thiourea derivatives and aniline derivatives. In the first of these groups, and in decreasing order of activity, were thiourea itself, 2-thiouracil, 2-thiobarbituric acid, *sym*-diethyl-thiourea and 5-benzal-2-thiohydantoin; the second group included sulphonamides, *o*-, *m*-, and *p*-amino-benzoic acids *p*-aminophenylacetic acid and *p*-aminoacetanilide. The objective in the use of these compounds is to reduce thyroxine synthesis to the normal level in thyrotoxicosis, and the above-mentioned compounds are thought to interfere with an enzyme system

at some point in the complex chain of events within the body that leads to the synthesis of the hormone thyroxine. 2-thiouracil has been found particularly useful in clinical tests in this country and in America. It is now available in this country for use in certain and controlled conditions.

d-Desoxyephedrine, the "pervitin" with which members of the Wehrmacht are stimu-

lated to greater effort, is now recommended in America in the form of desoxy-ephedronium-sulphathiazole to relieve, and shorten the duration of the common cold; while racemic dioxyephedrine jointly with diphenyl-piperidino-propane hydrochloride and *p*-oxyphenyl-methylamino-propanol hydrochloride has been introduced into Germany as an antispasmodic in the relief of asthma.

Blood clotting is now becoming controllable through the use of the liver extractive heparin and of the synthetic dicoumarin. Dicoumarin (3 : 3¹-methylene-bis-(4-hydroxy-coumarin)) produces its hypoprothrombinaemic effect within 24 hours when it is administered orally. The effect is not hastened



Dicoumarin

by injection. It has been found that only those analogues which yield salicyclic acid or an orthohydroxy-benzoic acid derivative on degradation are capable of producing the anticoagulant effect. Link and his co-workers have found that a dicoumarin-like effect can be produced in rats with salicylic acid itself so long as they are fed on a basal diet low in vitamin K, and a similar result can be obtained in man even when the diet is not thus restricted. However, the simultaneous administration of vitamin K or its naphthaquinone analogue prevents the fall in prothrombin level in man, although vitamin K is not very effective in dicoumarin-produced haemorrhages. A significant point is that acetylsalicylic acid is even more effective in this respect than is salicylic acid itself. Considerable discussion has taken place during the past year on the production of haematemesis by aspirin, and it is thought to be due to a local irritation of the gastric mucosa. Active steps have been taken to reduce this irritant action in a number of proprietary preparations of aspirin. The question now arises as to how far this action of salicylic acid and its derivatives is due to the reduction of the prothrombin level of the blood. It is suggested (*Lancet*, 2/10/43) that there may be good ground for administering vitamin K or its synthetic analogues simultaneously with salicylates.

Among miscellaneous substances, the following recent introductions are to be noted. Insulin is now available in combination with globin and with a trace of zinc; in onset and duration of effect the preparation is intermediate between unmodified insulin and protamin insulin with zinc. McCallum and Sivertz, from experiments with rabbits, have found the effect of administration of insulin is enhanced some ten times by the parallel administration of amino-sulphone compounds of the sulphonamide group. Dihydrocholin, recommended for the treatment of bilary insufficiency, is now available in this country in place of the preparation previously imported from Germany. The instability and the consequent toxicity of the arsenicals has been obviated in a preparation now offered of arsphenoxide tartrate, a pure crystalline substance which can be allowed to stand in solution for up to eight hours without discoloration or increase in toxicity. Parallel with this finding, American workers have observed that morphine tartrate is the only salt of this alkaloid which remained without discoloration of, or precipitate-formation in, the solution when stored in single doses in tin containers attached to hypodermic needles for periods of 1½ to 2 years. After clinical tests by the Therapeutic Trials Committee of the Medical Research Council, α-phenyl-β-(4-hydroxy 3 : 5-di-iodo-phenyl) propionic acid is available as a contrast agent in cholecystography and it is claimed to be preferred and better tolerated than iodophthalein. "Lethane," an insecticidal aliphatic isothiocyanate imported under Lease-Lend arrangements, is available for use in medicated hair-oils. Tetra-ethylthiuram monosulphide has been found by Clayton to be effective in the treatment of scabies. *p*-Benzylphenyl carbamate, previously imported from Germany, is available as an anthelmintic and it is said not to have the undesirable toxic effects associated with the use of santonin.

Control of agar is to be enforced under a new Order of the Ministry of Supply (S.R. & O. 1740, 1943). The Order covers such substances as agar, Chinese gelatine and Japanese isinglass, and also any mucilaginous product derived from nine named genera of seaweed. Preparations made from Irish moss (*Chondrus crispus*) are excluded, as well as material treated before December 28, 1943, so as to render it unfit for bacteriological use.

Fuel and the Carbonising Industry in 1943

by G. E. FOXWELL, D.Sc., F.Inst.P.

Dr. G. E Foxwell.

THE outlook of the carbonising industries during the past year has depended very much on the purpose for which the carbonisation has been effected. While this is, of course, always true to some extent, it has been particularly true this year because of the shortage of coal supplies. The coal position has dominated the field as never before. Low-temperature carbonisation during the war has been confined to one or two companies only. The smallest companies generally closed down their activities soon after the war started, largely because they found their coal supplies diverted to other uses, and those companies which have maintained their position have in general had to be content with reduced output. The coke-oven industry has been able to operate to full capacity because it has been supplying coke to the steel works, and gas to the gas industry and to the steel works. Nevertheless, the demand for coke is not as great as the production, especially in the summer, and considerable stocks of oven coke have accumulated in certain parts of the country. The demand for gas, however, is pretty well maintained.

The Gas Industry

The gas industry has been in the most difficult position of all. Gasworks have, in general, not been able to increase their capacity to any extent during the war, but, on the other hand, the majority of gas undertakings have found themselves either with an influx of population or with considerable additional demands from war factories, and generally with both simultaneously. It has been found possible to make a great deal more gas with the same plant, but of course this has meant that the plant has been worked harder and that time has not been allowed for repairs. The difficulty of the position thus created has been aggravated by the curious policy of the Coal Supplies Division of the Ministry of Fuel and Power. For some strange reason it seems to have been supposed that works on high priority must have only the very best coal. Generally a coal fairly high in ash content (say, 10 to 15 per cent.) is perfectly suitable for mechanical firing, and indeed has been described as ideal for that purpose. Provided that the quality of successive deliveries of coal, and more particularly its size, remain reasonably uniform, there is no difficulty in burning almost anything, so long as the fuel is reasonably suited to the type of grate in use. The difficulty has been that works which did not need it have been provided with nice clean gas coals for burning on their boilers, while the gas industry, although a very essential munition industry in that it supplies fuels to 3000 different trades, has found itself short of suitable coals. The coals supplied have often been very high in ash and have frequently been of a quality and size not generally considered as suitable for coal carbonisation. The result has been that the gas industry has had a remarkably difficult task to maintain the gas supply during the year; great credit is due to the carbonising industries as a whole for what they have accomplished.

Labour has been short in supply and variable in quality. Many of the best men have been taken for other work or for the Forces and this has intensified the difficulties under which the industry has laboured.

Less Fuel Available

The 10-per-cent. cut in coal supplies to industry which was announced towards the end of the year must cause everyone connected with industry to think very carefully about the efficient use of their fuel. To cut down production is, of course, the very last thing that anyone wants to do to-day, but if there is 10 per cent. less fuel available and no large stocks, the only thing to be done if production is not to be hindered is to use the fuel more efficiently, *i.e.*, to get 10 per cent. greater output of steam, metal, chemicals, or whatever it may be, with the same amount of coal. In many installations this is simply a matter of attending to faults, faults which were not obvious to those who were operating them, but which can be immediately pointed out by a visiting engineer possessing a specialist knowledge of fuel technology.

There are many works, however, which have already received visits from fuel engineers, or which may themselves have qualified fuel engineers. The difficulties of getting higher efficiency out of existing coal supplies are then considerably greater and,

in imposing the cut, there is no doubt that the Ministry will take into account not only the importance of the work that is being done, but the steps taken to make the existing plant more efficient. It may be that the solution of the problem is to put in more efficient plant, and it is now common knowledge that the various Ministries concerned are able to take a broader view of what plant can be allowed.

The Ministry of Fuel and Power has published some 27 bulletins on the subject of the efficient use of fuel, and these bulletins are available free of charge from the Ministry. There is also in course of preparation a comprehensive *Stoker's Manual* which should be in the hands of every man who fires a boiler either for steam-raising purposes or for central heating; it is expected that this will be published within the next month or two. There is also shortly to be published a comprehensive textbook entitled *The Efficient Use of Fuel*, for which it is understood that orders can now be received at the Ministry at a price of 7s. 6d. a copy. The Fuel Economy Committee is to be congratulated on the high level of the technical efforts that it has made to improve the efficient use of fuel throughout the country. Extended reference was made to the work of this committee in THE CHEMICAL AGE on January 9, 1943 (p. 60); all the measures there described have continued in active application through the year.

Outcrop Coal

Outcrop coal has been mined as long as there has been a coal-mining industry in this country. It was obviously the first coal to be used because it was through outcrops that coal was discovered. True, such coal crops out on to the surface and is thus highly weathered, the result of weathering being that it becomes friable and easily breaks down into smalls and dust on handling; it loses its coking power; and it generally decreases in calorific value, owing to the formation of carbon dioxide, water vapour, and carboxylic acids. Surface oxidation of the outcrop is brought about by direct combination with the oxygen of the air; farther in, the air cannot penetrate, or at least not until it has oxidised the coal near the surface. A certain amount of oxygen, however, percolates through the overlying soill and clay dissolved in rain water and a slow oxidation may take place here unless an impervious stratum is superimposed on the coal. Also, as the seam goes deeper, whether because of the rising ground or the slope of the seam, the opportunity for percolation of water is reduced. The general result of all these factors is that as one gets farther in from the surface, the coal becomes less oxidised, and it often happens that within 100 yards or so from the outcrop, the coal is equal in character to that of the customary deep seam. In one example, 20 ft. from the outcrop a coal was found to have a calorific value of 8000 B.Th.U./lb. of dry coal; 100 ft. in from the outcrop its calorific value was 14,000 B.Th.U., which was virtually equal to that of the same seam worked by a colliery half a mile away.

Prejudiced by its Name

These facts regarding outcrop coal are mentioned because a great deal of such coal has been won during the last year, and this quantity is likely to be increased pretty considerably during 1944. The seriousness of the present coal-supply position means that industry will have to take more outcrop coal than it has in the past. There have been loud objections to using this coal, and partly in order to meet these objections on the ground that the dog has been hanged by having a bad name, it has been rechristened "open-cast" coal. Coal can strictly be called outcrop coal only when it comes from the few feet immediately adjacent to the surface where it crops out. It is called open-cast coal because the method of getting it is to remove the overburden by mechanical excavators, and then to dig out the coal by the same means. The principal difficulty in using open-cast coal, as we may now call it, is that people think it is not the same as ordinary coal and are immediately prejudiced against it. It has been suggested that if the coal were sold by the name of its seam and not under the title of open-cast coal, most of the difficulties would disappear. All the experience of coal salesmen shows that there is a very great deal in this contention.

The difficulty of using open-cast coal is not, however, wholly psychological. It arises from two prime reasons. The first is its size and the second its variability in quality. It is now customary to screen open-cast coal into two sizes, above and below 2 in.; and there is a tendency to increase the number of sizes by dividing the smaller coal into 2 ins.—1 in. and 1 in.—0 in. sizes. This, of course, implies the provision of screening plants at each site, but will considerably improve the efficiency with which open-cast coal can be used. It has been proved beyond doubt that, provided that the size of open-cast coal supplied is similar to that of normal pit coal supplied to the same appliances, the two coals behave in exactly the same way.

Open-cast coal has generally no coking property, though the coal farther from the surface may possess distinct caking powers depending on whether it has been oxidised or not. It may not, therefore, be suitable for a coking stoker, but it should be suitable for every type of stoker and appliance for which a free-burning coal is used. It is high in volatile matter and generally needs a good draught. Difficulties have been found

with the super-Economic boiler operating with a very short grate; carbon may be dumped in the ashes in rather excessive quantities and cause the grate dumping arrangements to become overheated.

Two warnings are necessary in regard to using open-cast coal. The first of these is that if the coal is not good in quality, *i.e.*, if it is low in calorific value or high in ash, it is generally advisable to mix it with the normal coal supplies. When this is done the mixing should be reasonably good. For example, alternate waggon loads or alternate lorry loads should be tipped into the receiving bunker; the coals will then be reasonably mixed during their passage to the furnaces. What should be avoided is a supply of open-cast coal for two or three days followed by two or three days' supply of normal coal; this does not mix and the result is varying qualities of coal which the firemen cannot anticipate. A second warning is that open-cast coal should never be stored. One of the primary effects of storing coal is that it tends to form slack, and open-cast coal, being already weathered, is friable and is particularly apt to form dust or slack.

Coal Conservation

One of the outstanding publications of the year has been the Report on Post-War Planning of the gas industry. This was discussed and described in THE CHEMICAL AGE on November 6 and 13, and it is not necessary to make detailed reference to its provisions here beyond stating that in our opinion this Report might well serve as a model on which the organisation of other industries could be based. It visualises government of the industry by the industry with a view to improving its value to the consumer. Powerful arguments are given against nationalisation and the importance of the carbonising industries is fully brought out. There can be little doubt that coal conservation is likely to be the keynote of our post-war fuel policy. Closely linked to this is the problem of smoke abolition, the purification of the atmosphere. We should not be surprised if purification of the atmosphere did not receive the same attention in years to come as purification of water does to-day. The carbonising industry and the electrical industry can alone produce large quantities of smokeless fuels at the moment; though, of course, the comparatively small amount of smokeless coals available must not be forgotten.

One of the features of the year was the growing realisation that the erstwhile competition between the fuel industries is out of date. There are technical reasons why one fuel is better for a particular purpose than another. It can be argued, for example, that from the coal-conservation angle electricity should not be used for domestic heating, unless the efficiency of electrical generating stations can be doubled or trebled. Each fuel, in short, has its particular sphere. The gas industry in its Report visualised the formation of a National Fuel Advisory Council. The function of this Council would be to review the technical and economic factors that operate in the production of heat services, and to give agreed directions on technical and economic grounds for the expansion of the various fuel industries for domestic and industrial purposes. Such expansion would be partly in the way of additional heating, but would consist principally in the displacement of raw coal.

It seems difficult to reconcile general displacement of raw coal with the present set-up of the coal industry. Just what the future will bring remains uncertain. Before the war, coal-selling schemes were put into operation with Government approval, which had the effect of enabling the coal industry to dictate to the customer what coal he should have. This was no doubt very convenient for the coal salesmen who retained his customers without having to trouble himself about retaining their goodwill. It prevented the best use being made of the nation's coal supplies, however, and the more scientific coal-using industries have never been happy with the position thus created. Certain sections of the coal industry are desirous of perpetuating the use of raw coal, largely, apparently, because that is the line of least resistance. Fuel technologists for the most part believe that a certain amount of raw coal will continue to be burnt because there are appliances available for burning raw coal very efficiently. There are many purposes, however, for which raw coal could be profitably replaced by fuels manufactured from coal. It would seem desirable that these conversions should take place without any sales-resistance from the coal industry. It may be possible to cause the coal industry to acquiesce in what is done; if so, all will be well. It may, however, be found to be necessary to take more active measures, and there are some who believe that from the point of view of coal-conservation nothing less than nationalisation of the industry will suffice.

Phenols for Roadmaking

The chemical development of the carbonising industry has made no special progress during the year under review. It was not to be expected that anything very striking would be developed in wartime, and if developed it could not be published. Perhaps tar has shown the most "liveliness" in some ways. The use of tar for roads has been improved by a process for making road surfaces from cold wet sand and aggregate by the use of lime and phenols derived from the tar. This process can be applied to bitumen provided that a proportion of

creosote containing phenols is added. The phenol appears to adhere to the water, by reason of its affinity with the OH group, and the lime to the stone, the result being the emulsification of the water in the tar or bitumen, and the more or less complete wetting of the stone by the tar in preference to the water. This process was described as new by a Government research organisation in a paper before the Institution of Civil Engineers, but it is claimed that the same process has been known in a similar form for some years and that roads have been successfully laid down in Leeds, using the earlier lime-phenol process. The Leeds process was developed by Mr. Hodsman of Leeds University, and is said to be ready for commercial application.

Low-temperature Tars

Low Temperature Carbonisation, Ltd., are apparently developing low-temperature tars for chemical purposes, according to a speech by Colonel Bristow, reviewed in THE CHEMICAL AGE on May 8. The particular properties of low-temperature tar are beginning to be understood. Its high content of tar acids immediately suggests the manufacture of plastics and of chemicals which might well lay the basis of a great export trade. It has often been argued in this journal that our country should build up a great organic chemical industry. Such an industry is being built up in America, based on petroleum and particularly on the gases from the oil wells and from the refineries. These gases consist very largely of methane, which at present is not a suitable material for further synthesis, and it is on the other hydrocarbon gases of low molecular weight that petroleum technique is at present concentrated. For reasons into which we need not enter here it appears that the petroleum industry is unable or unwilling to embark upon a parallel development in this country. We possess raw material in the shape of coal; unfortunately, we are allowing those "practical" men who run our affairs to treat coal as a sort of refuse that can be burnt instead of as a chemical raw material. The nearest approach to products of petroleum on which this practical chemical industry is being developed is the product derived from the low-temperature carbonisation of coal. Col. Bristow stated that up to 97 per cent. by weight of low-temperature gases consist of methane, ethane, and ethylene, and that from three existing low-temperature plants some 14,000 tons of ethylene are produced a year.

The position in organic chemistry has now reached the stage at which the chemist can obtain almost anything he wishes, starting from the two elements carbon and hydrogen and adding others as needed. It happens that when these elements are presented to him in the form of methane he cannot at the moment do very much with them, but in almost any other form he can convert them into whatever substance he desires. As Dr. Stine has remarked: "By the addition of oxygen and other elements in the proper combination there can be obtained alcohols, esters, acids, solvents, perfumes, pharmaceutical chemicals, and synthetic organic bodies of every type. Catalytic cracking processes and adaptations of them, brought very recently to high stages of performance, are now leading towards this goal and taking petroleum chemistry into a realm once exclusive to coal-tar chemistry." If through the intervention of low-temperature carbonisation we in this country can achieve a parallel development to that taking place in America, there is every justification for putting the process on a new basis. A great deal depends on the yield of the required products and the scale on which the British chemical industry is prepared to make use of them.

It is to be expected that considerable research activity will follow the appointment of Dr. J. G. King, of the Fuel Research Station, to be the Director of Research to the Gas Research Board. Dr. King has still to build up his organisation and to erect his central research laboratories, and immediate results cannot be expected. Dr. King visualises (according to a speech delivered by him at Birmingham) work in collaboration with the various interests that are developing by-products—tar distillers, sulphate of ammonia concerns, the National Benzole Association, and so forth—close collaboration with the universities; a survey of coals suitable for the gas industry; the production of more combustible coke; development of really good coke-burning appliances; continued research into complete gasification and the Lurgi process; the synthesis of methane, its liquefaction and storage, and its use as a motor fuel; the production of oils and unsaturated compounds by the Fischer-Tropsch process; in short a large and comprehensive programme on the chemical utilisation of coal and the better use of the gas, coke, and other products derived from carbonisation. The chemistry and physics of gas utilisation must rank high in priority.

Coking Problems

The coal industry has, of course, already set up the B.C.U.R.A. laboratories. This body has held conferences, one on the ultra-fine structure of coals, which appeared to produce little new material, but rather to show that experimental evidence confirmed previous ideas and work. B.C.U.R.A. has also received a very large grant for the investigation of the possible chemical uses of coal. This investigation may overlap that of the Gas Research Board. It may well result in the development of an organic

chemical industry based on coal processing. The coke-oven section of the carbonising industries is to be congratulated on a forward policy during the year. The British Hard Coke Association now represents the interests of almost every coking plant throughout the country. This Association, in collaboration with the Coke Oven Managers' Association and the National Association of Coke and By-Product Plant Owners, has set up a committee which is in process of forming a research association for the coke-oven industry. At the time of writing no announcement has been made, but one is expected—possibly before these notes appear in print.

There have been several difficulties, due to war conditions, in connection with the coking process. One of the most striking has been the effect of leaving standing ovens carbonised and thus at a high temperature. The ash from the coal has penetrated into the brickwork and has not infrequently set up deterioration of silica bricks, probably through the presence of ferrous silicates at high temperature. This difficulty is not met normally, but it indicates that increased attention should be given to the selection of coals for coking, such as the reduction of the ash content to the minimum, the drying of the slack down to at least 7 per cent. of water, and the avoidance of unnecessarily expanding coals. Clearly, a good deal of work remains to be done in connection with the coke, because even in these days of fuel scarcity coke is plentiful, and in some districts it is even a problem to dispose of it. The President of the Coke-Oven Managers' Association, Mr. J. Bradwell, has ascribed this to "the unattractiveness of the product and the lack of efficient appliances for its satisfactory use." In many respects he sees the same problems before the coke-oven industry as Dr. King has seen to be facing the Gas Research Board though, of course, all problems are not common to both industries and the emphasis is different. Clearly, the Gas Research Board and the Coke-Oven Research Association must work in close collaboration, and it is to be expected that carbonisation research in general will be concentrated ultimately in a joint committee set up by these two bodies.

The general conclusion from this survey of fuel and carbonisation is that the country is beginning to be fully alive to the need for coal conservation and for the abolition of smoke. Industry is now being forced to consider fuel economy as it has never done before; the high costs that will prevail after the war will undoubtedly cause this policy to be continued. It seems very probable that the Ministry of Fuel and Power or a National Fuel Advisory Council must continue in the national interest the work now being done by the Fuel Efficiency Committee. The carbonising industries, which must always be the principal suppliers of smokeless fuels, and will probably for long remain the principal coal-processing industries, are fully alive to their problems and are prepared to engage on research on a scale never before attempted. The future for these industries is full of promise.

LETTER TO THE EDITOR

Chemical Engineering Group

SIR,—I noted a reference to the Chemical Engineering Group *vis à vis* the Instituton of Chemical Engineers in the interesting editorial in your issue of December 25, 1943. I do not think it is any heresy to hold the view that the former organisation is redundant, but such is not, I believe, the view held by the members of the Council of the Institution.

The Group has a definite rôle and there is no rivalry or jealousy between the two bodies in question. The Group deals more with the practical and operational side of chemical engineering, while the Institution endeavours to obtain papers of a more fundamental and scientific character. Further, anyone interested in chemical engineering and works practice and chemical manufacture generally, can, via the Society of Chemical Industry, become a member of the Group, while the portals of the Institution are only open to engineers who have had a thorough theoretical training. That may not always have been the position, but it is so to-day. Young men starting on their training, managers and foremen, can all become members of the Group and keep in close touch with chemical engineering even if they cannot gain admission to the Institution.

The Group has no vested interest to protect or axe to grind, but exists for the general good of a class of technical men and as old members continue loyal and new ones are coming in steadily I think its existence is justified.—Yours faithfully,

R. F. STEWART.
Hon. Sec., Chemical Engineering Group, S.C.I.

December 31, 1943.

The quarterly bulletin of the Institution of Chemical Engineers gives the names of those nominated by the Council as candidates for election at the annual corporate meeting, which takes place in April. The present president, vice-presidents, joint hon. secretaries, and hon. treasurer are all standing for re-election, with the exception of SIR HUGH BEAVER; the nominee for this vacancy is SIR ALFRED EGERTON. MESSRS. W. F. CAREY, R. GILMOUR, V. F. GLOAG and F. A. WILLCOX are nominated for election as council members.

News Events of 1943

JANUARY

THE Colonial Office established the Colonial Products Research Council, with Professor J. L. Simonsen as its research director.

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The Association of Scientific Workers held a London conference on "The Planning of Science." The proceedings were later published in book form.

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Dr. F. S. Sinnatt, F.R.S., F.I.C., director of the Fuel Research Station, Greenwich, died at the age of 62.

FEBRUARY

MR E. A. G. LIDDIARD was appointed research manager of the British Non-Ferrous Metals Research Association.

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Strict control of Germany's nitrogen-fixation industry after the war was advocated by Sir Robert Robinson as an effective means of preventing her rearmament.

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Dr. Per K. Frolich was elected president of the American Chemical Society.

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It was announced that a large-scale trial of food-yeast production by a process developed at the Chemical Research Laboratory, Teddington, would be made in Jamaica. A new giant strain of yeast, obtained by treating *Torulopsis utilis* with camphor, was also mentioned.

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On February 13, THE CHEMICAL AGE published a letter, subscribed to by over 140 chemists, calling for greater co-operation between the existing chemical organisations. It envisaged the formation of a federal body to achieve co-ordination in seven major functions, and expressed the belief that "it is essential to the performance of these functions that there should be a common secretariat, a Central House and close co-operation in all centres between bodies promoting the interests of chemistry and chemists."

MARCH

DR. HAROLD MOORE received the Institute of Metals Medal for "outstanding services to non-ferrous metallurgy."

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An exhibition showing new uses for glass was opened at the Building Centre in London. It was arranged by the Department of Glass Technology of Sheffield University, in conjunction with the Glass Manufacturers' Federation, and has since toured the provinces.

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Dr. E. W. Smith resigned the post of Director-General of Gas Supply at the Ministry of Fuel.

Professor Alexander Findlay was elected president of the Institute of Chemistry.

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Mr. S. Ernest Melling, F.I.C., was elected president of the Society of Public Analysts.

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The M.B.E. was awarded to Mr. Eric Shaw, a Manchester works chemist, and to Mr. R. A. Warburton, chemist with I.C.I. (Explosives), Ltd., for bravery in fires involving explosives.

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The British Association held a London conference on the subject of "Science and the Citizen."

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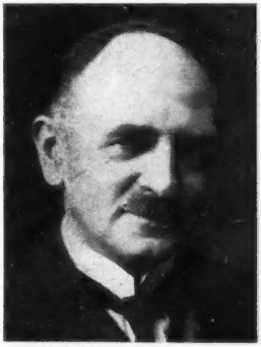
New Fellows of the Royal Society included Dr. A. J. Ewins, research director of May & Baker, Ltd.; Dr. J. J. Fox, Government chemist; Professor G. A. R. Kon of the Royal Cancer Hospital; and Dr. Charles Sykes of the Metallurgy Department, N.P.L.



Mr. F. A. Greene.

The death was announced of Dr. Harold Gordon Rule, lecturer in chemistry at Edinburgh University.

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Dr. W. Lee Lewis, who perfected the poison gas known as "Lewisite," died at Evanston, U.S.A.

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The R.A.F. bombed the molybdenum plant at Knaben, near Kristiansand, Norway, on March 3.

APRIL

MR. F. A. GREENE succeeded Mr. C. S. Garland as president of the Institution of Chemical Engineers.

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Dr. J. G. King became research director of the Gas Research Board.

The death was announced of Dr. Alfred Archibald Boon, professor of chemistry at Heriot-Watt College, Edinburgh, at the age of 81.

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The first plant to produce butadiene from petroleum for America's synthetic rubber programme went into production at Baton Rouge, Louisiana.

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Dr. A. Parker was appointed Director of Fuel Research in the D.S.I.R.

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Twelve new plants started production of synthetic rubber and petrol in Germany.

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The award of the Edward Medal was announced to Dr. Wilson C. G. Baldwin, Mr. William Sallows, and Mr. Frank H. Wheeler, for their brave action when an explosion occurred in the nitrating house of an explosives factory.

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To promote the advancement of photography in all branches of science, an Association of Scientific Photography was formed.

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The Institute of Physics held a conference on X-ray Analysis at Cambridge, which was attended by 200 scientists.

MAY

PROFESSOR A. C. CHIBNALL was chosen to succeed Sir Frederick Gowland Hopkins, whose impending retirement from the Sir William Dunn professorship of biochemistry at Cambridge was announced.

Mr. Wallace P. Cohoe.

The Chemical Society elected Professors Linus Pauling, Nikolai Semenov, and Nikolai Zelinsky as honorary fellows.

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The Parliamentary and Scientific Committee issued a report on the utilisation of our coal resources, and stressed the need for intensified research.

At the annual council meeting of the Association of Scientific Workers, Sir Robert Watson-Watt, the president, replied to critics who accused the organisation of being political by saying that those who believed political scientists were a menace to science and to the community had forgotten how fundamental politics really were.

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Dr. E. D. Hughes was appointed Professor of Chemistry at the University College of North Wales.

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Sir John Russell, director of Rothamsted Experimental Station for 31 years, was awarded the Albert Medal of the Royal Society of Arts.

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The Institute of Chemistry became "The Royal Institute of Chemistry of Great Britain and Ireland."

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Dr. Karl T. Compton, director of the Massachusetts Institute of Technology, delivered the 1943 Pilgrim Trust Lecture to the Royal Society, in which he outlined the organisation of American science for war purposes.

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The R.A.F. dropped 1500 tons of high explosives on Wuppertal, a German town with important chemical factories.

JUNE

THE Institute of Physics published a significant report on the training of physicists.

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Dr. W. G. Ogg was appointed to succeed Sir John Russell as director of Rothamsted.

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Sir Edward Appleton, secretary of the D.S.I.R., opened the new physico-chemical research laboratories of the B.C.U.R.A.

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The sixth "magnesium from brine" plant of the Dow Magnesium Corporation started production at Marysville, Michigan.

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Dr. E. S. Grumell, chairman of the Fuel Efficiency Committee of the Ministry of Fuel and formerly head of the I.C.I. coal research laboratories, was awarded the Melchett Medal of the Institute of Fuel.

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Germany's second largest synthetic-rubber factory, situated at Hüls, was bombed by Flying Fortresses.

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The Society of Chemical Industry elected Academician Alexei Bach and Dr. Te Pang-Hou as honorary members.

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Use of RDX, an explosive 35 per cent. more powerful than TNT, was announced by the Chief of U.S. Army Ordnance.

JULY

TEN Chinese graduates, including several chemists, arrived in Britain as guests of the British Council to study British production methods.

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At the 62nd annual meeting of the Society of Chemical Industry, Mr. Wallace P. Cohoe was elected president. In his address the 1943 S.C.I. Medallist, Dr. L. H. Lampitt dealt with the need for greater co-operation among chemical organisations. Speaking of the training of chemists, he commented that specialists were being bred at the expense of scientists.

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British scientists announced that they would raise £3000 to equip the laboratory of the new Stalingrad hospital.

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Standard Oil transferred permanently to the U.S. Government the patent rights in Buna-S.

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Mr. W. Esmond Wornum was re-elected president of the Oil and Colour Chemists' Association for the fourth time.

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Dr. Vannevar Bush, director of the American Office of Scientific Research and Development, visited Britain and was given a formal reception at the Royal Society.

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Questions were asked in Parliament about a British firm that was confident it could produce synthetic rubber, was ready to instal the plant, but was denied the consent of the Minister of Production to do so. Mr. Garro Jones, on behalf of the Minister, gave a non-committal answer.

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Rothamsted Experimental Station celebrated its centenary on July 21.

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A Chemistry Education Advisory Board was set up as the result of a conference held at the suggestion of the Chemical Council.

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The existence of two calcium carbide factories in Britain was revealed in Parliament by the Minister of Supply.

AUGUST

THE Chemical Council replied to the letter on chemical co-operation which attracted such attention when it was published in February. The Council stated that amendments to its constitution would be needed before any of the demands put forward in the letter could be met, with the exception of those concerning publications and publicity. The Council added that, in spite of the inevitability of altering its constitution, it was pursuing the matter, and would formulate a scheme of development for the Chemical Council for future consideration.

American magnesium plants were reported to be turning out more metal than was required, with the result that production in "magnesium from brine" factories had to be reduced by 25 per cent.

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Mr. W. C. Devereux, chairman and managing director of High Duty Alloys, Ltd., and Ocean Salts (Products), Ltd., published a pamphlet entitled "Post War Reconstruction in South Wales," in which he outlined the possibilities of an important electro-metallurgical industry being developed.

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Penicillin produced in the States was placed under Government control, being intended for use mainly in the Services.

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Sir James Morton, one of the outstanding figures in the development of the British dyestuffs industry, died on August 22.

Dr. L. H. Lampitt.

Germany's synthetic rubber output proved insufficient to meet her export commitments to Sweden.

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An official statement was made that in Britain penicillin supplies were inadequate to permit the use of this bacteriostic agent in the treatment of individual civilians, the shortage being due to the needs of the Services.

SEPTEMBER

FOR the second time in the history of the T.U.C., scientists were represented at the annual meeting of the congress. The Chemical Workers' Union gained T.U.C. affiliation at the conference.

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The Canadian Government approved expenditure to cover the establishment of plants in Montreal and Toronto for the initial production of 26,000,000,000 units of penicillin for use by the armed forces.

The Ministry of Supply released the names of chemists at Woolwich Arsenal who had been killed during the development of the explosive RDX.

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In Parliament, Mr. Garro Jones admitted that the Government was discussing plans for synthetic rubber production with a British company.

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Professor A. A. Read, Emiritus Professor of Metallurgy, University College of South Wales, died on September 24.

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An X-ray analysis group of the Institute of Physics was formed.

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About thirty buildings of the I.G Farben chemical works at Ludwigshaven were damaged by R.A.F. attack.

OCTOBER

AN electronic method of dehydration was reported from the U.S.A.

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The first all-synthetic rubber tyres were reported to be coming off American production lines.

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As a result of representations by the Canadian Institute of Chemistry, the word "chemist" was replaced by "pharmaceutical chemist" throughout the new Pharmacy Act of Ontario.

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The Parliamentary and Scientific Committee published a report on Scientific Research and the Universities in Post-War Britain, in which they proposed a treble increase of the annual Treasury grant to the universities.

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The death occurred on October 17, of Dr. W. H. Hatfield, technical research director of Thomas Firth and John Brown, Ltd.

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The Derbyshire Fluorspar Producers' Association was formed.

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The Federation of British Industries issued a report on industrial research prepared by a special committee under the chairmanship of Sir William Larke.

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At the 27th annual general meeting of the A.B.C.M., Dr. E. V. Evans and Dr. P. C. C. Isherwood were elected president and chairman respectively in succession to Mr. R. Duncalfe and Mr. C. F. Merriam.

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The British Laboratory Ware Association elected Mr. H. J. Hornby as its chairman.

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It was announced that nine factories in the States were to expand their penicillin production at a cost of more than $3,000,000.

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The Council of the Society of Chemical Industry appointed an exploratory committee to consider the possibilities of forming an English-speaking chemical union.

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The Parliamentary and Scientific Committee set up a sub-committee to consider the relation of income tax to research expenditure.

NOVEMBER

THE Ministry of Production granted a licence to British Celanese, Ltd., for bulk production of synthetic rubber in a north-country factory.

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Professor I. M. Heilbron was awarded the Davy Medal of the Royal Society for his researches in organic chemistry.

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The discovery of extensive helium deposits in New Mexico, near the Arizona border, was reported.

Dr. P. C. C. Isherwood.

Dr. C. J. T. Cronshaw and Mr.. D. R. Lawson were appointed directors of I.C.I., Ltd.

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The molybdenum mine at Knaben, Southern Norway, was heavily bombed for the second time within nine months. Other raids during November were made on the chemical-manufacturing centres of Ludwigshaven and Leverkusen.

DECEMBER

DR. A. P. M. FLEMING was elected president of the Plastics Industry.

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The Royal Society's president, Sir Henry Dale, urged the provision of an adequate central home for the various scientific societies in London.

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Sir Robert Pickard retired from the directorship of the British Cotton Industry Association's research station, and was succeeded by Dr. F. C. Toy.

Colloid-Chemical News of the Year

by J. J. BIKERMAN

THE volume of colloid-chemical publications shrank again in the fourth year of war. Among the few books on colloids issued this year the new edition of Dr. Clayton's well-known treatise on *The Theory of Emulsions and their Technical Treatment*, should be mentioned.

Dr. Brunauer published in U.S.A. a book on *The Adsorption of Gases and Vapours* (Vol. I: *Physical Adsorption*; Princeton Univ. Press; pp. 511) in which presumably—the reviewer had as yet no opportunity of seeing it—the present knowledge of gas adsorption was summarised from the standpoint of the theory worked out by Brunauer and collaborators. Within a few months of this summary a paper appeared, levelling a sharp criticism against the foundations of the theory. Kistler, Fisher and Freeman (*J. Am. Chem. Soc.*, 1943, *65*, 1909) point out that the theory involves the assumption that, if the number of molecules present in the first adsorbed layer is n, then that of the molecules in the second layer is an, in the third a^2n, etc., a being a function of the heat of evaporation of the vapour adsorbed, and of its vapour pressure (or gas pressure). If, *e.g.*, the heat of evaporation and the vapour pressure are such that $a = 0.1$, then for every 10,000 molecules in the first layer there would be 1000 molecules in the second, 100 in the third, 10 in the fourth, and there would be one molecule in the fifth layer. No reason is known for believing in such a "pyramid-like" structure of adsorbed substances.

Adsorption Theories

Brunauer's theory contradicts also his own conclusions as to the specific surface area (*i.e.*, the surface area of 1 gm.) of adsorbents, which were reported—following a review by Emmett—in THE CHEMICAL AGE a year ago. Since the value of a can be calculated independently of any adsorption measurement, it is possible to calculate also the number of molecules in every layer when the first one is complete. In two examples worked out by Kistler the total amount adsorbed was 11 per cent. and 62 per cent. more than that contained in the first layer. In the method used by Brunauer and Emmett a point on the adsorption isotherm is selected which is supposed to represent a complete unimolecular layer; from the volume adsorbed at that point and the known cross-section of the molecules, the area of the adsorbent is computed. The computation is obviously wrong if 11-62 per cent. of the adsorbed amount is outside the unimolecular layer.

It was claimed for the theory that it accounted for all the various types of adsorption isotherms observed; the five basic types (*see* Brunauer *et al.*, *J. Am. Chem. Soc.*, 1940, *62*, 1723) are shown in Fig. 1. But the fit obtained between theory and experiment seems to be due, at least partly, to the fact that the theoretical equations contain four adjustable constants. Kistler interprets adsorption isotherms from the point of view of capillary condensation. He pictures, *e.g.*, a silica gel as a felt of silica fibres; in the very narrow spaces between the crossing fibres water is trapped as seen, on a larger scale, in innumerable instances of daily life. On a large scale this

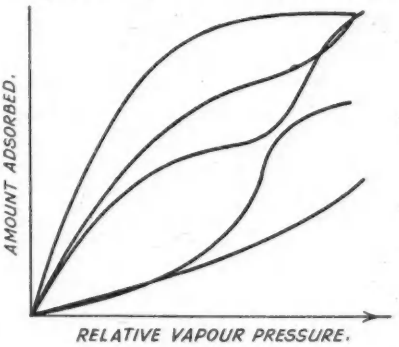


Fig. 1

effect is well known and cannot be disregarded, but we know so little about the submicroscopical conditions on solid surfaces that there is much freedom for speculation.

Kistler says that capillary condensation "is a fact that can no more be questioned than the fact that liquids that wet the walls will rise in a narrow tube." Gregg (*J. Chem. Soc.*, 1942, 696; 1943, 351) concedes to capillary condensation only a very secondary place; in this his theory agrees with that of Brunauer's. But Gregg stresses the similarity between the adsorption isotherms of vapours on solids and those of insoluble films on the surfaces of liquids. This similarity is, of course, well known, Langmuir's adsorption theory being based on it, but Gregg follows it more closely than Langmuir did and believes he has detected in the adsorbed gases or vapours two or three allotropic transformations corresponding to transitions: gaseous film → liquid expanded film → intermediate state → liquid condensed film, which have been observed in the monolayers of soaps and oils on water surface. Also Gregg's theory allows a calculation of the specific surface area of an adsorbent. Only one example has been calculated by both Gregg and Brunauer, and

the values computed differ in the ratio of 1 to 3. It may be concluded that, for the time being, there is hardly a secure foundation for a general theory of gas adsorption, and the many important problems associated with adsorption—ranging from respirators to heterogeneous catalysis—must be tackled without reliable theoretical guidance.

Doubtful Assumptions

Perhaps the progress will be more rapid when more account is taken of the non-uniformity of all solid surfaces. They are non-uniform in at least three respects: geometry, crystallography, and chemistry. The geometrical non-uniformity is due to the roughness of all solids, and there is no doubt that the conditions of a vapour enclosed in a crack only a few molecules wide are different from those of a vapour adsorbed on a plane open to atmosphere. The crystallographic non-uniformity is caused by the fact that on practically every surface different crystal corners, edges and faces are exposed, every one of which has an individual capacity for adsorbing and retaining foreign molecules. The chemical non-uniformity is produced by casual " dirt," oxides, etc., which are present on all surfaces, unless exceptionally well cleaned *in vacuo*; and the adsorptive capacity obviously varies with the chemical composition of the adsorbing surface.

When the specific surface area is computed from adsorption measurements it is assumed that a point on, or a point found by an extrapolation of, the adsorption isotherm represents a complete unimolecular covering of the adsorbent by the gas or vapour. In view of the non-uniformity of all solid surfaces it is questionable whether such a point exists at all. To take a very exaggerated example, in lithography a surface consisting of hydrophilic and hydrophobic areas is brought in contact with an oily medium (printing ink); when the contact ceases, the hydrophobic areas are seen to be coated with a thick (thousands of molecules) layer of ink, whereas the hydrophilic ones have "adsorbed" no ink at all. Evidently, it would be futile to calculate the thickness of the " adsorbed " layer by dividing the amount of ink which remains attached by the total surface of the lithographic stone. True, there is no reason for suspecting differences of this magnitude between different areas of a laboratory adsorbent, but smaller differences of similar kind are very probable, and the adsorbed layer may in reality look almost as chequered as a pattern on a lithographic stone.

A uniform solid surface is often assumed also in the discussions of other phenomena and it seems to be worth while to test the legitimacy of this assumption before accepting any results based on it. Lubrication is one of the phenomena to which the preceding remark applies. It has been suggested by many scientists and engineers that the " oiliness " of a lubricant is connected with the orientation of its molecules on the surfaces of the moving parts. But it could be shown (Bikerman, *J. Soc. Chem. Ind.*, 1943, *62*, 41) that, in a particular method of measuring " oiliness," it was really the roughness of the solids in contact that was measured, and it was made probable that a more detailed consideration of the shape and structure of solid surfaces might be helpful in clearing up the " oiliness " problem.

The rate of adsorption of streaming vapours by charcoal has been measured by Zabezhinski (*Russ. J. Phys. Chem.*, 1943, *17*, 32). A molecule of vapour has (a) to reach the surface of a charcoal grain; (b) to diffuse inside a pore in it to a point on the internal surface; and (c) to get adsorbed there; and the problem is which of these processes takes longest and, consequently, determines the rate of adsorption. If (c) is the rate-determining process, the vapour concentration within the pores is always equal to that in the ambient atmosphere, and the rate of adsorption is independent of the grain size and the velocity of the vapour stream. If (b) is the slowest stage, the rate would be a function mainly of the size and texture of single grains; and if the rate depends on (a) it is independent of the grain size and texture, but is a function of the velocity of the vapour stream and of the geometry of the apparatus. In Zabazhinski's experiments charcoal was used in the form of small cylinders, about 2 mm. in diameter, each consisting of many grains; and it was found that the rate of adsorption and desorption of alcohol vapours varied inversely with the size of the cylinder, but did not depend much on the size and origin of the individual grains; and it increased with the velocity of the stream. In these experiments, therefore, the process (a) was operative.

Electrophoresis of Particles

Miss Bach (*Acta Physicochim*, 1941, *14*, 463) shows that charcoal activated in absence of oxygen and immersed in a 0.005 *N* KCl solution adsorbs HCl, whereas a similar charcoal kept in contact with oxygen takes up KOH from a KCl solution. Concurrently with the change of the adsorptive capacity the charcoal suffers a change in its cataphoretic mobility. Non-oxidised specimens suspended in a solution move in a uniform electric field to the anode, at some medium degree of oxidation they move hardly at all, and when further oxidised, the movement proceeds to the cathode. The degree of oxidation corresponding to no movement very nearly coincides with that producing a charcoal which causes no hydrolysis of KCl.

Charcoal saturated with hydrogen moves to the anode, but the rate of movement depends on the acidity of the solution. When its *p*H increases by 1 (*i.e.*, the hydrogen ion concentration is lowered 10 times) the electrokinetic potential of charcoal becomes more negative by 0.003 volt. The electrode

potential of a hydrogen electrode (*e.g.*, of a carbon rod saturated with hydrogen) becomes more negative by 0.058 volt when the *p*H increases by 1. The difference between the values 0.003 and 0.058 volts is attributed by Miss Bach to the "topographic" difference between the potentials concerned; the electrode potential is the work done in transferring a charge from the interior of solution on to the carbon surface, whereas the electrokinetic potential measures only that part of this work which is spent when the transfer stops at the "slip boundary," *i.e.*, the theoretical boundary between a liquid layer adjacent to the solid and moving together with it, and the "free" liquid farther off. The physical meaning of this boundary has been discussed in a later paper (Bikerman, *J. Phys. Chem.*, 1942, *46*, 724), according to which the more or less "immobile layer" adjacent to the solid surface is another consequence of the surface roughness mentioned above; liquid entrapped among the "hills" and "valleys" on the surface is not free to move in smooth parallel layers predicted by the classical theory.

The electrophoretic movement of suspended particles is, naturally, closely related to the movement of ions in an electric field, and the electric conductivity of colloidal solutions can be treated on lines familiar from the study of ordinary ionic solutions. Bolam and Trivedi (*Trans. Farad. Soc.*, 1943, *39*, 247) investigated the variation of the conductivity of sulphur sols on dilution. The equivalent conductivity of ionic solutions generally increases with dilution, but that of sulphur sols decreases though very slightly. An interpretation of this result is made more difficult by the high concentration of the sols employed. If the original sol contains, say, 90 c.c. of aqueous solution and 10 c.c. of sulphur particles, and the diluted sol 99 c.c. of aqueous medium, and 1 c.c. of sulphur, it is not obvious whether we should refer the conductivity in both cases to 100 c.c. or to 90 c.c. in the first, and 99 c.c. in the second case: sulphur is, of course, a perfect insulator.

Rabinovich and collaborators (*Acta Physicochimica*, 1942, *17*, 25) measured the cataphoretic mobility of monodisperse gold sols (*i.e.*, sols having particles of one size only) in presence of variable amounts of potassium chloride, barium chloride, and aluminium chloride. Similar measurements have been done many times before, and, in accord with earlier results, Rabinovich found a gradual reduction of the mobility when the concentration of the added salt increased. He applied to his results the theory which attributes this reduction to the "shrinkage" of the double layer. The physical basis of this "shrinkage" discovered already by Gouy in 1910 can be explained very simply. Imagine a plane charged surface. From every charge a Faraday tube emerges into the free space; it ends when it meets an opposite charge. If there are only few opposite charges in the space, the tubes on the average have to protrude deeper in order to meet one; and if the concentration of charged particles in the space is high, the tubes, on the average, are short. Consequently, the electric double layer is thin in concentrated and thick in dilute ionic solutions. Since the potential of a double layer is proportional to the product of its charge and thickness, the potential is the smaller the more concentrated is the solution—if the charge remains constant. Rabinovich pointed out that in the case of his gold sols the decrease of the electrokinetic potential produced by addition of KCl was really such as if the charge on the particles remained constant and only the thickness of the double layer changed. The behaviour was different in presence of $BaCl_2$ or $AlCl_3$; here a variation of the particle charge had to be assumed as well, although a major part of the potential lowering was still due to the "shrinkage" of the double layer. These, and similar results published in many papers in earlier years, emphasise the fact that cataphoretic mobility is not a direct measure of the particle charge.

Since in the last year's report two American papers on the measurement of the particle size of powders have been discussed, two British papers on the same topic will be mentioned here. Rigden (*J. Soc. Chem. Ind.*, 1943, *62*, 1) describes a new apparatus for measuring the permeability of a powder for air—this permeability being greater as the pores between the powder grains are larger; and Jones and Barlow (*J. Soc. Chem. Ind.*, 1943, *62*, 129) introduce an improved sedimentometric balance.

SUPERSONICS IN METALLURGY

According to a recent German article (an abstract of which has been supplied by RTP3, Ministry of Aircraft Production), oxide film on aluminium sheets can be removed and proper anchoring of the "tinning" achieved by the use of supersonics. The sheet is immersed in a bath of molten metal which is subjected to high-frequency vibrations by contacting it with a supersonic generator; frequencies of the order of 12,000 cyc./sec. are employed and the intensity may amount to as much as 10 W./cm.^{2}. This subjects the contacting zinc particles to accelerations and decelerations of the order of 100 g. This process appears to destroy the oxide film and so enable the zinc particles to become firmly anchored on to the sheet. Other applications of supersonics in metallurgy mentioned in the paper are the production of finer grain in castings by exposing the melt to supersonic radiation during solidification, and the production of self-lubricating bronze containing about 25 per cent. graphite.—*J. Sci. Inst.*, December, 1943.

General News

Mineworkers throughout England and Wales have now contributed over £250,000 to the Red Cross Penny-a-Week Fund. Yorkshire miners still lead with a total of £62,300.

The price of tin sold by the Non-Ferrous Metals Control has been increased by £25 per ton from January 1. The price for metal of 99-99.75 per cent. tin content is now £300 per ton and other prices are varied correspondingly.

A lecture on a chemical engineering subject has been endowed by Mr. J. Arthur Reavell, and will be given under the auspices of the Institution of Chemical Engineers. The lecture will be known as "The J. Arthur Reavell Lecture", and will be delivered not less frequently than once in every four years.

Girl workers in a West of Scotland I.C.I. factory, who have "adopted" the Eighth Army, and frequently send comforts to the men, have presented a souvenir book to General Montgomery. The General, in accepting the book, has asked that it be handed to his mother until he has completed his "big job."

Two Trading with the Enemy Orders have been published in the first few days of 1944. These are the No. 17 Order (S.R. & O 1943, No. 1672) and the No. 18 Order (S.R. & O. 1943, No. 1734), the first being a consolidated Order comprising all Specified Persons Orders previously published, the second making amendments in the list of traders abroad, all dealings with whom are unlawful.

A forecast of the application of synthetic methods to the manufacture of the coarser, as well as of the finer, textile materials was made last week by Mr. A. J. Stewart, president of the Dundee Chamber of Commerce. He felt that this spelt opportunity rather than disaster to the jute industry, and if there was to be development on those lines, they should see that it was done in Dundee.

In the course of a recent address at Troedyrhiw, South Wales, Mr. S. O. Davies, M.P., said that every coal seam in South Wales was a potential oil well, but that the extraction of oil from coal was being held up by vested interests. The methods of obtaining the ever-increasing by-products from coal must be further developed and intensified. If we adopted the Russian method of gasification of coal it would no longer be necessary for miners to descend into the bowels of the earth. Shafts would be sunk, the coal veins would be fired, and the resulting gases collected and liquefied. The Welsh coalfield would have a great future if these new forms of power were fully exploited.

From Week to Week

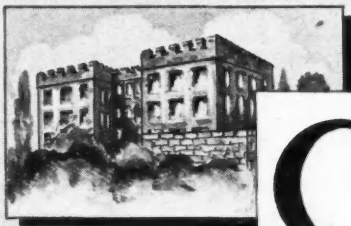
A second supplement to the Ministry of Supply's Raw Materials Guide has been published by the Stationery Office (price 1d.). It lists the names of over 200 chemicals which have been transferred to a different branch of Raw Material Control, and refers to recent orders affecting artificial fertiliser, non-ferrous metals and talc.

The third conference on "X-Ray Analysis in Industry" has been provisionally arranged to take place in Oxford on March 31 and April 1, under the auspices of the X-Ray Analysis group of the Institute of Physics. Details will be circulated shortly to members of the Group and will be sent to non-members on application to Dr. H. Lipson, Honorary Secretary of the Group, c/o Crystallographic Laboratory, Free School Lane, Cambridge. The conference will be open to all interested, but it may be necessary to limit the number of non-members.

Chemical and Allied Stocks and Shares

FIRM conditions have continued in most sections of the Stock Exchange. Values again tended to improve, although only a moderate volume of business was in evidence. Sentiment was encouraged by the war news, and by the favourable impression derived from recently-issued results and dividend announcements. Compared with a week ago, Imperial Chemical further improved from 38s. 9d. to 39s. On the basis of the 8 per cent. dividend which has ruled for some years, I.C.I. ordinary yield over 4 per cent., which is rather higher than the return on various other leading industrials, and the view continues in the market that there seem good prospects that the dividend will be maintained. Better demand was also reported for Borax Consolidated, which strengthened from 35s. 10½d. to 37s.; in this case the view prevails that the dividend is likely to be kept on a 7½ per cent. basis. Turner & Newall at 78s. 9d. were well maintained in price, while British Aluminium were higher on balance at 47s. 7½d., and British Oxygen rose further from 78s. 3d. to 80s. In view of the statements at the last meeting, there are continued hopes of the possibility that shareholders in the last-named company may have an offer of additional shares on favourable or bonus terms. Dunlop Rubber at 40s. 3d. were 3d. above the level current a week ago. Associated Cement were maintained at 63s. and British Plaster Board strengthened to 28s. 6d. Lever & Unilever moved higher to 36s. 3d.

There was rather less attention given to



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shares of companies connected with plastics, although De La Rue at 161s. 3d. were higher on balance. Erinoid 5s. ordinary remained at 10s. 6d. British Industrial Plastics 2s. ordinary were better at 6s. 9d. on consideration of the financial results. Owing to the large amount provided for taxes, the good increase in this company's trading profits is not reflected in net profits, and, as previously announced, the dividend is unchanged at 8 per cent. Elsewhere, Lewis Berger were higher at 92s., while at 33s. 7½d. Pinchin Johnson were unchanged on balance. At the time of writing, International Paint have improved from 110s. to 111s. 3d. Cellon were again 23s. and Titanine 2s. shares around 7s., while elsewhere, Goodlass Wall 10s. ordinary strengthened to 16s. 3d. There was again a fair amount of activity in British Celanese, which at 29s. were higher on balance, although best prices touched in the past few days were not fully maintained. Compared with a week ago, Courtaulds have moved up from 52s. 6d. to 53s. 3d. at the time of writing. Elsewhere, Bradford Dyers improved further to 22s. 3d. and Calico Printers to 16s. 9d. The market remains hopeful that Bradford Dyers may resume dividends during the current year.

Iron and steel securities maintained the better tendency which developed recently; Dorman Long were higher at 29s., Guest Keen again 33s., Staveley 48s. 9d., Stewarts & Lloyds 52s. 7½d., United Steel 24s. 7½d., and Tube Investments were better at 91s. 6d. In other directions, B. Laporte were 75s. and W. J. Bush 60s. The 4 per cent. debentures of the last-named company transferred around par. Greeff-Chemicals 5s. ordinary were 7s. 3d. and Monsanto Chemicals 5½ per cent. preference 23s. 6d. Boots Drug have been well maintained at 41s. 6d. Sangers improved to 23s. 10½d. and Timothy Whites were 33s. 6d. The units of the Distillers Co. further improved to 88s. 6d. Wall Paper Manufacturers deferred were little changed at 39s. 9d. Nairn & Greenwich held their recent rise to 67s. 6d. pending the dividend announcement, while Barry & Staines recorded a further gain from 44s. 9d. to 45s. Elsewhere, Low Temperature Carbonisation 2s. shares were better at 2s. 7½d. Demand was in evidence for Gas Light & Coke ordinary, which were 19s. 4½d. compared with 18s. 9d. a week ago. Oil shares moved better; the " Shell " interim dividend announcement is impending.

British Chemical Prices

Market Reports

THE price position throughout the London general chemicals market continues at recent levels and movements in rates, where they have occurred, have been within narrow limits. The flow of business during the first week of the New Year has been steady, with no slackening in contract deliveries. In most sections of the market the supply position remains the chief centre of interest, and spot offers of a number of potash and soda products are exceedingly scarce. There has been a steady demand for the lead oxides and an active trade is passing in formaldehyde. In the coal-tar products section contract deliveries are being called for in substantial quantities and in many cases production is already earmarked to meet forward requirements.

MANCHESTER.—Busier conditions have been reported on the Manchester chemical market during the past week, but it has been much less a matter of new business than the circulation of delivery specifications against existing contracts. There has been a certain amount of fresh inquiry in the market and some additional business has been placed, but it has not been of very great consequence, users in many instances being already reasonably well covered forward. Taking the market as a whole, prices are firm but unchanged on balance. In the tar products new buying has been relatively quiet, but in most directions contract deliveries have been on steady lines.

Price Changes

Arsenic.—99/100%, under 1 ton, £62; 1 ton, £61; white 98/99%, £59; grey 96/97%, £54; grey 95/96%, £52; crude, £35 per ton.

Creosote.—Home trade, 6½d. to 7d. per gal., f.o.r. maker's works.—MANCHESTER: 6¼d. to 9¾d. per gal.

Copper Sulphate.—£31 5s. per ton, f.o.b., less 2% in 2 cwt. bags.

Formaldehyde.—£24 to £27 per ton in casks, according to quantity, d/d.

Lactic Acid.—Pale tech., £47 per ton; dark tech., £40 per ton ex works; barrels returnable.

Lead, Red.—English, 5/10 cwt., £45 per ton; 10 cwt. to 1 ton, £44 15s.; 1/2 tons, £44 10s.; 2/5 tons, £44; 5/20 tons, £43 10s.; 20/100 tons,, £43; over 100 tons, £42 10s. per ton less 2½ per cent., carriage paid. Non-setting red lead, 10s. per ton dearer in each case.

Lead, White.—Dry English, less than 5 tons, £57; 5/15 tons, £53; 15/25 tons, £52 10s.; 25/50 tons, £52; 50/200 tons, £51 10s. per ton, less 5% carriage paid. Ground in oil, English, 5/9 cwt., £69; 10 cwt., £68 10s.; 1/2 tons, £67 10s.; 2/5 tons, £66; 5/10 tons, £64; 10/15 tons, £63; 15/25 tons, £62 10s.; 50/100 tons, £61 10s. per ton, less 5 per cent. carriage paid.

Linseed Oil.—Crude, £60 per ton, naked ex works.

Naphthalene.—Crude, ton lots, in sellers' bags, £6 6s. 8d. to £9 7s. 7d. per ton, according to m.p.; hot-pressed, £11 5s. per ton, in bulk ex works; purified crystals, £19 to £35 per ton. Controlled prices.

Potash, Caustic.—Solid, £65 10s. per ton for 1-ton lots; flake, £73 per ton for 1-ton lots.

Potassium Carbonate.—Calcined, 98/100%, £67 5s. per ton ex store; hydrated, £61 10s. per ton.

Potassium Prussiate.—Nominal.

Pyridine.—90/140°, 17s. to 17s. 6d. per gal.; 90/160°, 13s.—MANCHESTER, 13s. 6d. to 18s. per gal.

Rapeseed Oil.—Crude, £70 per ton, naked ex works.

Sodium Metasilicate.—£16 10s. per ton, d/d U.K. in ton lots.

Sodium Phosphate.—Di-sodium, £26 10s. per ton; tri-sodium, £30 per ton; d/d for ton lots.

Sodium Sulphate (Glauber Salt).—£4 10s. per ton d/d.

Toluol.—Pure, 2s. 7d. per gal.; 90s', 1s. 11d. per gal.

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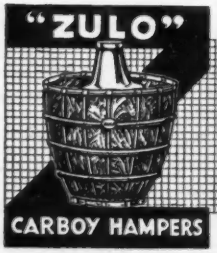

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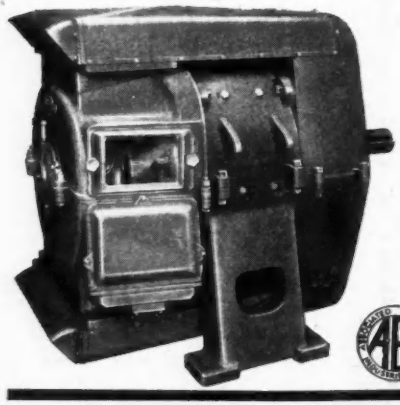

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